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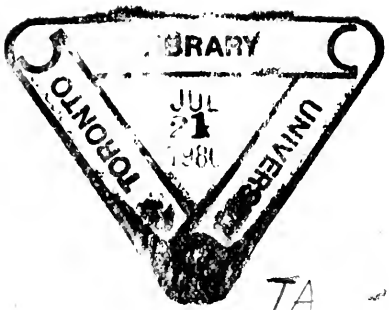


PREFACE.

THE three Papers contained in this Appendix to Vol. I. of the *Occasional Papers* were the first Papers that appeared under the new form, and were issued towards the close of 1876. As, however, they were neither printed uniformly, nor paged consecutively, it was not considered desirable that they should be included in Vol. I. for 1877, and they have, therefore, been bound together as an Appendix to it.

ROBERT H. VETCH,
CAPTAIN R.E.,
Secretary, R.E. Institute.

January. 1878.

CONTENTS.

PAPER I.

A SHORT ACCOUNT OF THE

CAMPAIGN IN THE MALAY PENINSULA,

INCLUDING THE OPERATIONS IN

PERAK AND JUNGHIE UJONG.

November, 1875—*February*, 1876.

By Lieut. H. B. Rich, R.E.

The following is a short account, written in the field, of the war in Perak up to the present time, but I must ask my readers to make allowances for any errors in dates, and other small details, as I myself did not join Major-General Colborne's force till just before the taking of Kinta, and consequently a great deal of what I write has only been recounted to me.

It is useless for me to trace all the causes which have given rise to this small war, for it has been already fully done by those who are in a position to know far more than I am. Suffice it then to say that the immediate cause was the murder of Mr. Birch, the British Resident in Perak.

The murder took place under the following circumstances:—Mr. Birch had gone up to Passir Sala, distant from the Residency at Banda Bahru about seven miles, and further up the river Perak, in order himself to fix up Proclamations showing the powers of the British Resident in the government of the country, &c. This occurred on the 2nd November, 1875, and he had, oddly enough, that morning telegraphed to the Governor of the Straits Settlements that all was quiet in Perak. About 9 a.m., after fixing up the Proclamations, Mr. Birch went into one of the small neat bath-houses on the river's bank to bathe; and, while there, some armed Malays tore down the Proclamations, stabbed his interpreter, and then made for the bath-house. Mr. Birch's servant alone got to the boat, and made

his escape down to the Residency. The last he saw concerning Mr Birch was the Malays thrusting their spears through the mat sides of the bath-house. The murdered body floated down the river, and was afterwards picked up and buried. A message was at once sent to Penang relating the murder, and asking for reinforcements. From Penang a telegram was sent to the Governor of the Straits Settlements, and the two telegrams, one to say all was quiet in Perak, and the other recounting the murder of Mr. Birch, arrived at Singapore at the same time. At the time of Mr. Birch's murder, Lieutenant Abbott, R.N., was on the opposite bank of the river shooting, and Mr. Swettenham, C.S., was at Qualla Kangsa on duty, and luckily they both got information of what had occurred, and in a most miraculous way safely ran the gauntlet down to the Residency, which they prepared to defend against all attacks.

The news of the murder arrived at Penang on the 4th inst., and a detachment of sixty men and two officers of the 1/10th regiment, under the command of Lieutenant Booth, 1/10th regiment, and accompanied by Capt. Innes, R.E., who was sent as Commissioner, left for the Residency in Perak. Captain Innes' appointment was that of Assistant Colonial Engineer, and he was stationed at Penang. This detachment arrived at the Residency (Banda Bahru) on Saturday, the 6th November, 1875, and on Sunday, the 7th inst. they started up the river to attack the Malays.

They landed at a point a little below Campong Baia, and marched up the bank of the river. When they reached the corn field (see *Plate* II.) at Campong Baia, they were suddenly fired into from the Campong Baia Stockade (a section of which is shown in *Plate* II.) which was entirely hidden by the corn. They then attempted to take this by assault, but were obliged to retire, as all their officers were either killed or wounded. Captain Innes, R.E., was shot through the heart, and Lieutenants Booth and Elliott were both wounded. There were also one of the 1/10th, one policeman, one Sikh, and one Malay ally killed; also, eight of the 1/10th wounded, one of whom afterwards died. The troops then retired to the Residency to await further reinforcements. These reinforcements in the shape of another detachment of the 1/10th, under Captain Whitla, 1/10th, a detachment of Royal Artillery with one gun (7-pounder rifled), under Lieutenant Monkton, R.A., also a Naval Brigade of about eighty men, with one 7-pounder rifled gun, two 12-pounder howitzers, and two 24-pounder Hale's rocket tubes, under the command of Commander Stirling, R.N., of H.M.S. "Thistle," arrived at the Residency on the 8th and 9th instants.

Then occurred a slight delay in preparing the boats for the guns, fitting them with temporary carriages, &c., and it was not until the 15th that all was ready.

On the 15th November, 1875, they all started up the river to attack the stockades. When they neared Campong Baia, the land force landed and marched up the shore, keeping pace with the boats.

They first opened a fire of shells and rockets from the boats, and then advancing, the land force captured the stockade without the loss of a man, the enemy flying before them. They then advanced further up the river, and in the same manner captured the stockades at Passir Sala. (For detailed account see separate account at the end of this paper.) During the whole day there was but one man wounded, and in all it may be said four stockades were taken, though one was of little note.

Plate II. shows the position of the stockades at Campong Baia and Passir Sala, as also their different sections.

After taking the stockades the troops burned all the houses, and destroyed as much of the stockades as possible, and then returned to the Residency to await further orders.

In the meantime the Governor of the Straits Settlements had telegraphed to Hong Kong and India for reinforcements to be sent at once. Accordingly General Colborne, with 300 men of the 80th regiment, and their proper complement of officers, left Hong Kong on the 11th November, 1875, and General Ross, with the 3rd Buffs, 400 men of the 1st Goorkhas, a battery of Royal Artillery, and one company of Madras Sappers and Miners, left Calcutta about the end of November, 1875. The remainder of the battery of Artillery then in Perak, left Singapore, under Major Nicholls, R.A., for the Residency in Perak.

It may be as well here to give the general plan of the proposed operations in Perak:—

General Colborne, with a force of about 200 men, was to advance from Banda Bahru (Residency) up the Perak river to Blanja (see *Plate* I.).

The Indian force, under General Ross, was to advance from Laroot to Qualla Kangsa.

These two forces were then to converge on Kinta, the chief town of the state, and attack it on the south and north.

It was also intended that a third force should cross from the mouth of the Bruas to Blanja; but this force was never organised, because of the outbreak in Junghie Ujong, Malacca, to which place

300 Goorkhas, 200 Buffs, and a half battery of Artillery had to be sent. We shall see hereafter how this plan was carried out, and to what extent :—

General Colborne arrived at the Residency (Banda Bahru) about the 24th November, 1875, and took the command of the whole of the troops. Captain Buller, R.N., of H.M.S. "Modeste," also arrived and took command of the naval brigade of about eighty men. Then came a short delay on account of the difficulty of procuring boats to transport the troops, guns, &c., up the river, and consequently the troops remained at Banda Bahru till the 8th December, 1875. It may be as well here to describe shortly the river Perak. This river is very broad and shallow, and gunboats drawing about nine feet of water can only get up to Durian Sabatan. Small steamers and launches can get as far as Kota Tumut. From this point native boats have to be employed, and these can with difficulty be propelled by means of long poles against a $2\frac{1}{2}$-mile current, making way at the rate of about one mile per hour. The banks, which in some places are below the level of the river, are very low and marshy until you reach Banda Bahru, where they become higher, and all the way up dense jungle reaches down to the water's edge on both banks. The bed of the river is full of sandbanks, which render the navigation most difficult and tedious. As an example of the difficulty of getting up the river, I can state that a boat with artillery on board took twelve hours to get from Durian Sabatan to Banda Bahru, a distance of about twelve miles.

Before beginning the march up the river, and at the time the General was at Banda Bahru, he garrisoned the village of Kota Stia with a detachment of fifty men of the 80th regiment under Lieut. Cole, 80th regiment, and the village of Passir Sala with a larger force of something over 100 men in all under Major Nicholls, R.A. It was intended to construct a road through the jungle from Kota Stia to Banda Bahru, but it was found to be impracticable, because the land all round lay below the level of the river, and could not be drained.

Between the 24th November and 8th December, at the time that the troops at Banda Bahru were waiting for boats, General Colborn gained information that Maharajah Lela, the supposed murderer of Mr. Birch, was close behind Kota Stia, and meant to try and make his escape there. Accordingly, General Colborne went down from Banda Bahru to Kota Stia with a force of 100 men. He then marched up the Dedaps (a small river, whose source is close behind Passir Sala) to a village not far from Kota Stia, where one of

Maharajah Lela's houses was situated. When he arrived there, all the inhabitants declared themselves friendly; therefore, having ascertained that Maharajah Lela was not there, and leaving a detachment of fifty men under Lieutenant Cole at Kota Stia, the General returned with his men to Banda Bahru.

I propose now to follow the march of General Colborne's force, and then trace out what I have since ascertained concerning General Ross' column:—

On the 8th December, 1875, a sufficient number of flat-bottomed boats having been obtained, General Colborne's force of about 200 men, accompanied by a naval brigade of about eighty men, under command of Captain Buller, R.N., of H.M.S. "Modeste," left Banda Bahru and halted and encamped at the end of their first day's march at Salat Polo, just above Passir Sala.

On the 9th, leaving a detachment of fifty men of the 80th under Lieutenant Prior, 80th regiment, at Passir Sala, they again advanced up the river, and, without opposition or occurrence of any note, they halted that night at Passir Garum. On the morning of the 10th they again advanced, and passing the large village of Zambok, which declared itself friendly, they encamped for the night at a place called Pulo Bakuy. On the 11th they again advanced, and at the large village of Bota the General and his staff landed to try and obtain news of the whereabouts of Maharajah Lela and ex-Sultan Ismail, who was supposed to be in league with Lela. He could gain no information until he tied some of the chief men of the village to a tree, preparatory to lashing them, when they told him Lela was about one day's march in front of our force; but their information was considered as useless. That night the troops halted at Tiam Tiam, a place a little above Bota.

The next day, the 12th inst., the troops advanced as far as Parrit, intending to attack Blanja the day after, at which place they expected opposition.

On the 13th they advanced cautiously on Blanja, and, contrary to expectation, they entered the place without opposition. At Blanja the General ascertained that ex-Sultan Ismail, who was harbouring Lela, had left for Kinta that morning.

At Blanja the General expected to hear news from Qualla Kangsa, but receiving none, he determined to leave a detachment at Blanja, and march at once through the jungle on Kinta. Accordingly, he left fifty men of the 1/10th under Lieutenant Huntly, 1/10th, at Blanja, and gave orders for the men to take with them only two days' provisions and their waterproof sheets, intending to march

into Kinta in one day, take it on the next day, and march back to Blanja on the following day. He arrived at this decision owing to erroneous information as to the distance of Kinta, and we shall see how far this idea was carried out :—

Thus, at about 9 a.m. on the morning of the 13th December, 1875, General Colborne, with about 150 men and the Naval Brigade (about eighty men), began his march through the jungle to Kinta. The detachment, Royal Artillery, had with them two 7-pounder rifled guns, and the Naval Brigade had two of Hale's rocket tubes.

Now, the only path through the jungle was nothing more than the roughest elephant track, full of deep holes and swamps, and not more than three feet wide in its widest parts. To add to the difficulties of this path the enemy had thrown across it large trees to impede our progress. Each day this pass became worse, and had it not been done it might have been judged impossible to bring guns along such a road. As it was, on the third march (the last through the jungle), the one gun that was taken on had to be dismounted, and both gun and carriage carried separately on the men's backs.

Too much praise cannot be bestowed on the gunners, who overcame these difficulties in their way, and who managed, after almost superhuman exertions, to get one gun to Kinta.

After leaving Blanja on the morning of the 13th inst., the troops advanced slowly about three miles without any occurrence taking place, and they naturally became a little careless. When about three miles from Blanja, the advanced guard was suddenly fired upon from a hastily formed stockade in the jungle, and placed in an admirable position for guarding the track. The enemy fired two or three volleys, and in the mean time a gun and rocket tube were brought up and got into position.

Two rounds of shell and one of case shot were then fired into the stockade, as also two rockets; several rounds of the Martini-Henry were also fired, as the advanced guard advanced. The enemy retreated forthwith. By the greatest good fortune only one man, Doctor Randall, who was at the time marching along just ahead of the advance guard, was injured. He was wounded in the thigh. The troops then continued their march, and were only able that day to get as far as the first camping ground in the jungle (see *Plate* I.), which has no name. When the halt was sounded, the men, one and all, lay down where they stood, and slept all night on soaking wet ground, just as they were, in their accoutrements, they were so dead beat from their hard march.

The troops remained encamped at this place all next day and

night, while the General sent back word to Blanja for fresh supplies of rations to be sent on at once, for it was found that the idea of getting to Kinta in one day was quite impracticable, and it was impossible to move on in the impenetrable jungle without a further supply of rations.

On the 14th a friendly Rajah, Rajah Mahmoud, who was acting in concert with our troops, marched on with his men to Pappin, and having driven the enemy from the mines at Pappin, he sent back word reporting on the road, &c.

On the 15th instant our troops again advanced, and that evening, after a terrible march, arrived and encamped at the Pappin mines without any opposition.

Here again it was found imperative to make a halt of a whole day, on account of the slowness with which the supplies from Blanja arrived. This tardiness is to be accounted for by the extreme difficulty of procuring coolies to carry the supplies, and it was found necessary to make use of the men who had poled up the boats.

The camping ground at Pappin was as bad as it could be, and both soldiers and officers lay in the mud on their waterproof sheets, the officers in a small dilapidated mat hut, and the soldiers and sailors under temporary coverings made with large leaves.

Thus the troops remained encamped at Pappin during the whole of the 16th instant, when Rajah Mahmoud, as before, went forward accompanied by Mr. Swettenham, C. S. (Commissioner), as far as a large paddy field (see *Plate* III.), about a quarter of a mile from Kinta. They sent back reporting the road to be worse than on the two previous marches, and stating that they considered the guns would have to be carried. They also asked for a detachment to be sent on as early as possible the following morning to their assistance.

Accordingly, on the morning of the 17th a detachment of the 1/10th under Lieutenant Paton, 1/10th, accompanied by Surgeon-Major Gage, started for Kinta about 4 a.m. They arrived at the paddy field above mentioned about 9 a.m., and prepared to resist an attack, which was expected from the enemy.

Mr. Swettenham had already sent a messenger back that morning saying the enemy were firing at them, and to hasten on the troops.

About daybreak on the 17th instant, General Colborne's force moved from Pappin on to Kinta, but it was found impossible to carry both guns, so one of the 7-pounder rifled gun was left at Pappin under a guard.

As reported, the track on this day was found to be worse than on the previous days, and in consequence the march was very slow.

About three miles from Kinta, the messenger above mentioned brought the news to the General that the enemy were firing on the troops in the paddy field. He at once took a rocket tube and some of the Naval Brigade with him, and hurried on towards Kinta, having given orders for the gun to move up at once, and follow as fast as possible. He arrived in the paddy field (see *Plate* III.), about 10 a.m. The rocket tube was at once got into position (A, see *Plate* III.) on a commanding hillock, and two or three rounds fired at a point in the trees, where the enemy were supposed to have a large stockade. The troops then rested until the arrival of the gun, which came up in the course of half an hour, as well as the remainder of the troops. Then began the shelling of the town of Kinta. After shelling and firing rockets into Kinta for some time, the whole force cautiously advanced through the jungle towards the town, and they gained the bank of the river Kinta without opposition; when they arrived within sight of the town the enemy opened fire on them, but this was soon silenced by shells and rockets. After a short time the order was given to skirmish through the town along both banks. This was effected without resistance, the enemy having retired before us, and thus Kinta fell into our hands.

The General then gave orders for all the houses on the right bank of the river to be burnt, and we encamped for the night.

(A more detailed description of the taking of Kinta will be found at the end of this paper).

The troops after this remained encamped at Kinta. Having completed the object of the march, and having no other place to attack, they awaited further instructions from the Governor.

I must now follow, as well as I can, the movements of General Ross' column, but I can only give an outline of these, as very little information concerning them is available.

Colonel Cox with two companies (200 men) of the Buffs was the first to land at Larut, and he landed about the 27th November, 1875. He at once started for Qualla Kangsa, which he reached in four marches about the 12th December, 1875, and he forthwith formed an encampment there and awaited further orders.

Colonel Storey, with 100 men of the 1st Goorkhas next landed at Larut about the 7th December, and he also marched on to Qualla Kangsa, reaching it about the 14th December. He was accompanied by a half battery of Artillery, under Captain Gwyn, R.A.

General Ross landed at Larut about the 7th or 8th December, and he reached Qualla Kangsa about the 15th December.

The delay at Qualla Kangsa up to this time was due to the want

of transport, nothing being done towards getting boats until the arrival of General Ross.

On his arrival he at once proceeded to procure boats to convey some of the troops to Blanja, where it seems he intended to meet General Colborne's column. Why the original plan of marching from Qualla Kangsa through the jungle on Kinta was abandoned does not appear, but it is supposed that it was thought to be impracticable. To procure boats General Ross sent a party of the Naval Brigade under Lieutenant Wright, R.N., of H. M. S. "Modeste," down the river Perak. This party did capture and take back several boats without any opposition.

On the 19th December (at which time it will be noticed General Colborne's force were already in Kinta, having taken possession of it on the 17th inst.) Colonel Storey, of 1st Goorkhas, with fifty Goorkhas, 100 of the Buffs, and a Naval Brigade of fifty or sixty men with one of Hale's rocket tubes under Lieutenant Wright, R.N., left Qualla Kangsa for Blanja, where they arrived the same evening. Considering that these troops were able to get from Qualla Kangsa to Blanja in one day, whilst it took General Colborne's force five days to get from Banda Bahru to the same place, there seems to be no excuse for their not arriving in time to join General Colborne's force at Blanja.

When Colonel Storey found that General Colborne was already in Kinta, there was nothing left for him to do but to follow there as soon as possible, which he accordingly did, leaving the Naval Brigade at Blanja.

He marched across the jungle from Blanja to Kinta in two marches, arriving at the latter on the 21st December, 1876.

It may here be mentioned that the remainder of the Goorkhas, 350 men, on landing at Penang, were at once sent down to Malacca, in which place we will hereafter follow their steps.

Thus we see that by the 17th December, 1875, our troops had, in a military point of view, got possession of the whole of Perak. They commanded the rivers Perak and Kinta, and were in possession of all the chief towns.

At the beginning of January, General Colborne, after holding a consultation at Kinta with General Ross and the Queen's Commissioner, Major M'Nair, who came down from Qualla Kangsa for the purpose, left Kinta under the command of Colonel Storey, and proceeded to Penang to obtain instructions concerning further movements, from the Governor.

It may be as well to mention that since the Rajahs of the two

villages higher up the Kinta (Campong Timboo and Epu) came in and declared themselves friendly, and since it was of no use to try and follow Maharajah Lela and ex-Sultan Ismail in the jungle, there was nothing more for General Colborne to effect at Kinta.

Since the taking, Kinta has remained quite quiet, and up to the present date there is nothing of importance to relate concerning it.

But there is more to be recounted of the force at Qualla Kangsa.

On the 4th January, 1876, it was determined to go up to, attack, and search the village of Kota Lama, which is situated about three miles above Qualla Kangsa, and which has for a long time been known to be the haunt of all the very worst characters in Perak.

The force from Qualla Kangsa advanced on Kota Lama in the following manner :—

Part of the force skirmished up the right bank, and another part were sent across the river to skirmish up the left bank. The men on the right skirmished up to the part of the village on that bank without opposition, and placing a double line of sentries all round the outskirts they entered the village. Here the Commissioner summoned the head men of the village, and began talking to them. While they were thus engaged they heard firing on the left bank. which made the Malays very uneasy, but the Commissioner succeeded in pacifying them. The troops then searched this portion of the village, and took possession of 100 spears, eighty muskets, three barrels of powder, knives innumerable, and other minor weapons, which they afterwards carried back with them to Qualla Kangsa.

The party on the left bank had a harder time of it.

The Buffs skirmished along the bank, and the Goorkhas went a short distance inland, and skirmished through the jungle. The enemy several times fired at these skirmishers, but with no effect, and they advanced right through the village, which was apparently deserted, the enemy retiring into the jungle surrounding it.

General Ross and his staff who had followed the skirmishers up the river, thinking the village cleared, landed on the left bank about the centre of the village. He had with him but four Goorkhas as escort, but twenty sailors also joined the group. They were standing close to a house full of women and children, and Major M'Nair, the Commissioner, was explaining to these that they need fear nothing, when suddenly a party of Malays after firing a volley at the group, rushed from the jungle, and nearly succeeded in surrounding them. They were driven off after a short time. In the fray we lost Major Hawkins, the Brigade Major, one marine, one

sailor, and one Goorkha killed; also, Doctor Townshend and two Goorkhas wounded.

The troops then burned a large portion of the town, and that night returned to Qualla Kangsa. The troubles in this portion of Perak were not yet over. On the 19th January a party of fifty armed Malays attacked and murdered one Malay policeman and an officer's servant who were proceeding from Qualla Kangsa to Campong Baia.

In the mean time the Sappers and Miners under the directions of Lieutenant Hare, R.E., had begun to construct a road up the right bank of the Perak to Kata Lama. This working party was covered by fifteen skirmishers of the 1st Goorkhas. About the same time three boats had crossed above and three below Qualla Kangsa, from the left to the right bank of the Perak, full of armed Malays. Some of these advanced one day to within fifteen yards of the road-making party and fired into them, wounding a Sergeant of Sappers and a Goorkha. The Goorkhas returned the fire, but the Malays escaped in the jungle. These incidents show both the danger and difficulty of jungle fighting, and also that the country round Qualla Kangsa was in a very hostile state.

Considering this, another attack was planned at Kota Lama, and on the 28th January it was carried out. The troops skirmished up to the village as before, and after firing some rockets and shells into it which silenced the enemy's fire, they skirmished through the town. They then burnt the remaining portions, and that night returned to Qualla Kangsa. The troops are now engaged in building a strong stockade at Kota Lama. The manner of skirmishing up the village may be interesting to some readers. It was done in the form of a hollow square, with a line of skirmishers in rear. At a halt all the skirmishers faced outwards.

The success of this manœuvring is shown, by the fact that was afterwards heard. A hostile Rajah with an armed force were following the whole day the skirmishing party, trying to get an opportunity to fire on them, in which they totally failed.

There is little more to add, for the war appears over, and the troops are simply waiting to know whether the state is to be annexed or not. In case of annexation, of course they will have to garrison the chief towns, but if not, they will all shortly leave the country, as has been done in Junghie Ujong.

HENRY B. RICH,
Lieut., R.E.

ACCOUNT OF THE SECOND ATTACK ON PASSIR SALA AND CAMPONG BAIA.

About 5 a.m. on the morning of the 15th November, 1875, the troops embarked at Banda Bahru in the boats, which had been prepared for them, to attack the strong stockade at Campong Baia (where, it must be borne in mind, one detachment had already been defeated) and Passir Sala.

The whole of the troops were divided into two separate forces, a land force under Captain Whitla, 1/10th regiment, and a river force under Commander Stirling, of H.M.S. "Thistle."

The land force consisted of a detachment of Royal Artillery under Lieutenant Monckton, R.A., with one 7-pounder rifled gun, about eighty men of the 1/10th regiment, and a number of Sikhs and native policemen.

The river force consisted of a naval brigade, with one 7-pounder rifled gun, two 12-pounder howitzers, and two 24-pounder Hale's rocket tubes, for all of which carriages had been fitted up in the boats as well as possible. The two forces advanced together up the river until they came to within $1\frac{1}{2}$ miles of Campong Baia stockade, (see *Plate* II.). Here the land force landed and marched up the right bank of the river, the advanced guard keeping in a line with the leading boats. When these latter came within range of the stockade they brought up the guns and rockets into position, and began a heavy fire of shells and rockets into the stockade. When the enemy's fire was somewhat silenced, the land force advanced, and bringing their gun to bear on the stockade, fired into it. As soon as the enemy's fire ceased, the land force advanced on the stockade skirmishing, and they entered and took this stockade without the loss of a man, the enemy flying before them.

After taking the stockade at Campong Baia, the force advanced farther up the river in the same manner as before, and at last came upon the strong stockades at Passir Sala; the land force having encountered a slight resistance at a small stockade on the way. As they approached Passir Sala the enemy began firing on them, but the same manœuvres as before were here again repeated, and after a time the land force entered the stockades without the loss of a man. There was little or no resistance made at the stockade round Maharajah Lela's house.

During the whole day we had but one man wounded.

Plate II. shows the positions of the stockades at Campong Baia and Passir Sala, as, also, the various sections of the same.

H.B.R.

ACCOUNT OF THE TAKING OF KINTA.

NOTE.—*For a sketch of the town and surrounding country see Plate III., from which the nature of the attack will be better understood.*

About 10 a.m., the General, with some sailors and a rocket tube, arrived in the corn-field, about $\frac{1}{4}$ of a mile from the town of Kinta. (This field, as has been before stated, was already in the possession of an ally Rajah). The rocket tube was at once got into position on the rising ground at A, and two or three rockets fired at the position B, where the enemy were supposed to have a strong stockade. This could not be seen, but the positions, as also that of the town of Kinta, and D, the residence of a hostile Rajah, were very accurately pointed out by our Malay allies.

By this time the remainder of the troops had come up, and the gun was got into position at A.

The gun then fired a shell into the town of Kinta, and two at the position D. Each time the good effect of our shots was testified to by the yells of the enemy.

Then began in earnest the shelling and firing rockets into Kinta, each shot being answered by yells from the enemy.

After having fired at the town for some time, the General determined to advance, which was very cautiously done along the jungle path to the south of the corn field, and they arrived at C on the banks of the river unmolested. Here some of our troops crossed to the opposite bank, and awaited the order to advance into the town.

On arriving at the point C, and whilst some of our troops were in the act of crossing the river, several shots were fired from the north-east end of the town, E, but they fell short and splashed into the water in front of us.

We then got both the gun and the rocket into position at C, and again fired into the town silencing the enemy's fire. After a short time the order was given to advance in skirmishing order through the town, and our troops marched through these portions of the town on both banks without any resistance, the whole town having been utterly deserted. Thus ended the taking of Kinta, which also practically gave us possession of Perak. The Malays appear to have been terrified by our rockets and shells which were unknown missiles to them. They must have considered it impossible for us to bring a gun along such a track as that through the jungle to Kinta; and finding that we had accomplished what they thought impossible, they came to the conclusion that resistance was useless. Had we advanced on Kinta by the more direct route, that is, leaving the corn-field at the point F, and approaching the town from this, I believe we should have encountered more resistance, for we afterwards found they had here blocked up the path with immense trees.

H.B.R.

SKETCH OF THE CAMPAIGN IN JUNGHIE UJONG.

NOTE.—*I am unable to send a map of this portion of the country; in fact, I do not believe that, up to the present time, there have been any maps of Junghie Ujong and the surrounding country made.*

Having heard very little of the campaign carried on at Junghie Ujong, I can but give a very slight sketch of it:—

About the beginning of December, 1875, messages were sent to Singapore and Penang that the Malays had risen in Junghie Ujong, a small province to the N.E. of Malacca, and where, it may be remembered, there was a rising in 1874. This rising in 1874 was soon quelled by a detachment of the 1/10th regiment, and a Residency formed near Rassa.

Now, when in the beginning of December, 1875, the Malays in

Junghie Ujong followed the example of those in Perak, the garrison of the Residency, consisting of only 50 men of the 1/10th regiment under Lieutenant Hinxman, 1/10th regiment, was in great fear of being surrounded and cut to pieces. Lieutenant Hinxman at once telegraphed to Penang for reinforcements, at the same time calling up Lieutenant Peyton with a detachment (about thirty) of the 1/10th from Malacca to his assistance. Reinforcements, in the shape of about 300 Goorkhas, a half-battery of Artillery, and 200 Buffs, were at once ordered to Junghie Ujong under the command of Colonel Clay, of the 1st Goorkhas. In the mean time Lieuts. Hinxman and Peyton, with a small force of about 80 of the 1/10th regiment, and about forty auxiliary troops, marched from Rassa to attack the village of Paroa, where strong stockades had been erected. After the hardest fight of the whole war, and after suffering a great loss, they managed to take the village. The losses were forty-one killed and wounded out of 120 men, which, it will be noticed, was a very large average. (A detailed account of this battle will be found at the end of this paper).

After taking Paroa, they awaited the arrival of reinforcements before acting further. These reinforcements arrived about the 17th December, 1875. I regret that I cannot ascertain the exact numbers, but they were about—300 men of the 1st Goorkhas under Colonel Hill, a half-battery of Royal Artillery with two 7-pounder rifle guns, and two rocket tubes, under the command of Lieutenant Rigge, R.A., and also 200 men of the Buffs. The whole force was under the command of Colonel Clay, 1st Goorkhas.

These troops landed at Tukut, and at once proceeded to Rassa, where they were joined by the detachment of the 1/10th and a small Arab contingent under Captain de Fontanie.

The plan of operations seems to have been to march right into the heart of the enemy's country, burning and pilaging on the way.

Terrachee being the first town of note, it was determined to march on Terrachee in two columns.

The left column under the command of Colonel Hill, who had with him about 200 men with one gun and one rocket, was to make a detour through the jungle on the above place, and the right column under Colonel Clay, with the remainder of the troops (after leaving a garrison at Rassa), was to advance through the Bukit Putus pass by Bandole on the same point.

The object of advancing in two columns was both to impress the enemy with the amount of country which our force could cover, and to attack Terrachee on two sides. Besides, a very great reason for

dividing the force was, that in marching along the narrow jungle paths, a large force would extend over such a length of road, that the advance guard and rear guard would have been a very long way apart.

Colonel Clay advanced to Paroa, and on the afternoon of the 20th of December he sent out a party of twenty-five Goorkhas under Captain Channer, 1st Goorkhas, to reconnoitre. Captain Channer suddenly came upon a very strong stockade, and he went up to it and looked over the parapet into the interior without disturbing the Malays, who were at the time engaged at their evening meal. Captain Channer then attacked, and easily took possession of this stockade, with only the loss of one Goorkha killed, and one wounded. This stockade afterwards turned out to be that on the enemy's right flank, of three that defended the Bukit Putus pass. After taking the first stockade, Captain Channer began firing into the other two, and Colonel Clay hearing the firing sent out a large party to his assistance, and they then captured the other two stockades.

To this piece of good fortune and to the victory of Paroa may be mainly attributed the ease with which our troops afterwards marched through the enemy's country, for there is no doubt whatever, that the Malays, finding our force had so easily taken Paroa, and also without loss their immensely strong positions at Bukit Putus, became panic-stricken, and the fighting men refused again to oppose the white man, whom they had boasted they would drive into the sea.

To show the great good luck of so easily capturing the Bukit Putus pass, I must describe the situation. The road leading to Terrachee runs between two high hills of the Bandole Range at this pass. The pass is not more than three feet wide, and the hills on each side rise from it perpendicularly. About the centre of this pass there is a large mound about fifty feet high, round which the path runs; upon this mound was the centre and strongest stockade, which quite commanded the path. On each side of this stockade and a little in front of it were two other stockades, flanking the approaches. Add to this that the hills on both sides were covered with dense jungle, and that no gun of ours could be brought to bear on any of the stockades till within 100 yards of them, and you will note that this was a position that might be held by a few determined men for a very long time.

A great deal of praise is due to Captain Channer for the prompt way in which he captured the first stockade.

This was without doubt the enemy's strongest position, and it was the last stand they made.

On the 21st of December, Colonel Gray, having sent the Artillery on an hour before the time, marched through the Bukit Putus pass on to Bandole without opposition, and he encamped there for the night.

The next day on the 22nd instant, he marched through the beautiful valley of Terrachee, where it is said the foot of a white man has never before trod, into the town of Terrachee. They found that Colonel Hill's column, after a three days very tedious march through dense jungle, but without any opposition, had already arrived and encamped at Terrachee the evening before. On account of the difficulty of getting up supplies, both columns had to remain at Terrachee during the whole of the 22nd and 23rd instant.

On the 24th Colonel Clay determined on leaving a detachment at Terrachee to protect the communication with the rear, and advance again in two separate columns, for the reasons before stated.

Colonel Hill's column was to march to Gumatic in Dato Moar's territory, and after marching through this state was to join Colonel Clay again in Sri Menauti. Colonel Clay's column was to march by Parrit into the heart of Sri Menauti.

On account of the want of roads they both marched together as far as Parrit, when they divided into two columns. Colonel Hill's column marched up to Gumatic, which they entered without resistance, and thence they marched to the house of Dato Moara, where they fully expected some resistance to be made. He placed his men round the stockade and fired into it, but after firing a few shots the enemy retired, and our troops easily entered the stockade and bivouaced in it for the night. In the meantime Colonel Clay had marched right into the heart of Sri Menauti to Dato Antir's house, which he took without opposition, and he encamped there and awaited the arrival of Colonel Hill. On the 25th instant Colonel Hill's column joined that of Colonel Clay at the house of Dato Antir. This seems to have completed the campaign in Junghie Ujong.

During this victorious march the troops burned every village that was not friendly to us, and pillaged the country, with the object of showing the natives that they could not molest the British with impunity. No white man, it is said, had ever before penetrated into the rich countries of Terrachee or Sri Menauti, and it is to be hoped that the lesson given to the Malays on this occasion may be long remembered by them, and that they will in future think twice before they attempt to molest the English.

All the troops, with the exception of a strong detachment left at the Residency at Rassa, were almost immediately removed from this part of the country, and we may consider that the war in Junghie Ujong was over on the 25th December, 1875.

Great praise is due to the troops engaged in it for the prompt manner in which they followed up their first successes, and marched in a few days right into the heart of the Malay Peninsula.

Nothing further of any note has taken place in Perak, and the whole war is virtually ended. The troops are at present encamped in the chief towns in Perak awaiting further instructions.

H.B.R.

ACCOUNT OF THE TAKING OF PAROA.

On the 7th Dec., 1875, Lieut. Hinxman, 1/10th, commanding, accompanied by Lieutenant Peyton, 1/10 regiment, marched with their combined detachments of the 1/10th, about eighty men, together with about forty Sikh Policemen and Arabs from the Residency at Rassa, to attack the village of Paroa, the strength of which will be seen on reference to *Plate* IV. They had one gun with them. They took this gun with them as far as they could, but they found that it so impeded their progress that they determined to leave it in the jungle behind them. The attack was made in three separate columns (see *Plate* IV.); the right and left columns consisting of about twenty-five men each, and the main attack of the few of the 1/10th engaged, and the remainder of the Arabs, &c.

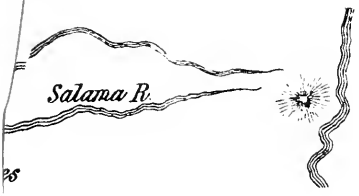
With the left attack we have nothing to do, for they lost their way in the jungle about the position shown on the plan, and were consequently never engaged. The main or centre attack advanced to the hillock marked A, and waited there to attack the village till they should hear shots on the right or left, showing that the attack on these points had begun. It will be noticed from the plan what an excellent position this hillock (A) would have afforded for the abandoned gun.

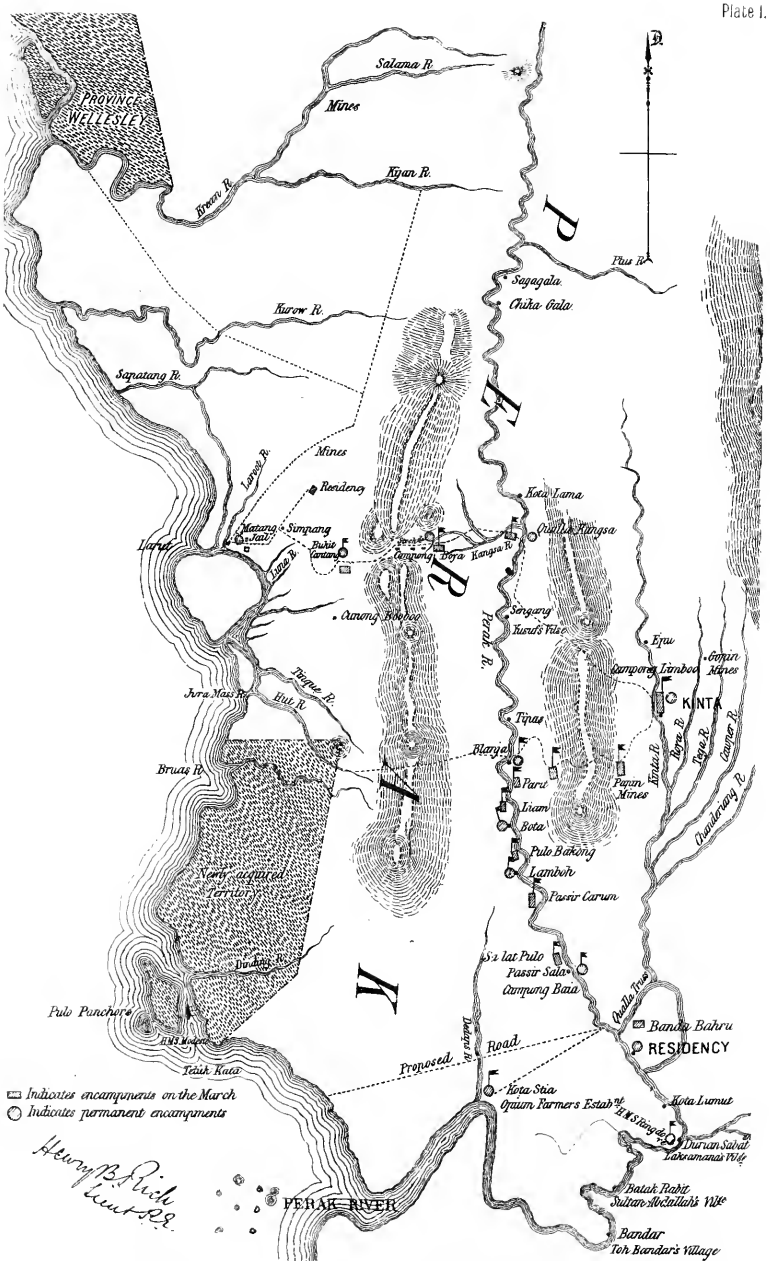
As soon as Lieutenant Hinxman heard the firing of the right column, who had begun their attack on the stockade B, and who afterwards took it, he began his advance on the centre of the village. As he advanced from A to C the Malays opened a very heavy fire

upon him, and killed and wounded a large number of his men, so much so that when the column arrived at C a consultation was held and the officers came to the conclusion to send back for the abandoned gun, which they at once did. In the mean time the line of attack was changed, on account of the impossibility of advancing direct on the village, and they diverged to attack first the stockade D. They took this stockade by storm; they then advanced to attack the salient E but were repulsed, and retired again into the stockade D. By this time the gun had been brought up and placed in position on A, and from there opened a heavy fire of shot and shell on the stockades in front of the village; at the same time a second attack from D on the salient E was made, and this time, owing probably to the assistance of the gun, was successful, Lieutenant Peyton entering at E with only five European soldiers and a few Sikhs. The enemy now became terrified and beat a hasty retreat in the jungle up the hill F. Thus was completed the taking of Paroa, which was the hardest fight of the war. I do not correctly remember the losses, but we lost about forty men killed and wounded out of 120 in all, which gives a very large percentage. The losses of the enemy are said to have been about 200.

From this fight will be seen how futile a thing it is to attack stockades without the assistance of guns and rockets: I say rockets, because these seem to terrify a savage enemy most,—he cannot understand them. Had our force in the first place been able to fire shell into the stockade from A, we should in all probability have taken the village with a very slight loss, as has been so often done in other cases during this war. I give this sketch of the battle from what I remember of a report on it sent here to General Colborne, and therefore, although the general features are correct, I must ask my readers to make allowances for any small errors.

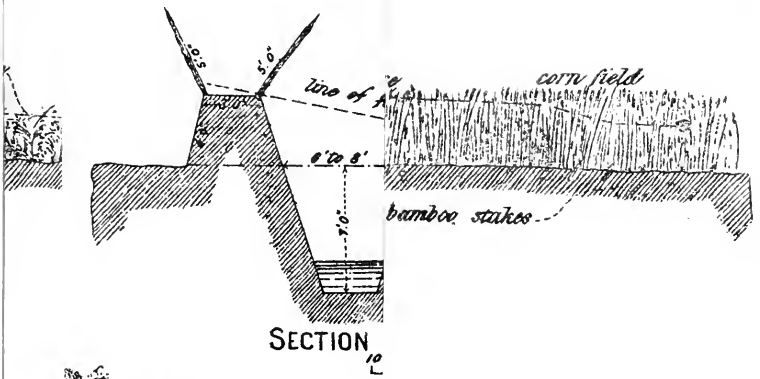
H.B.R.

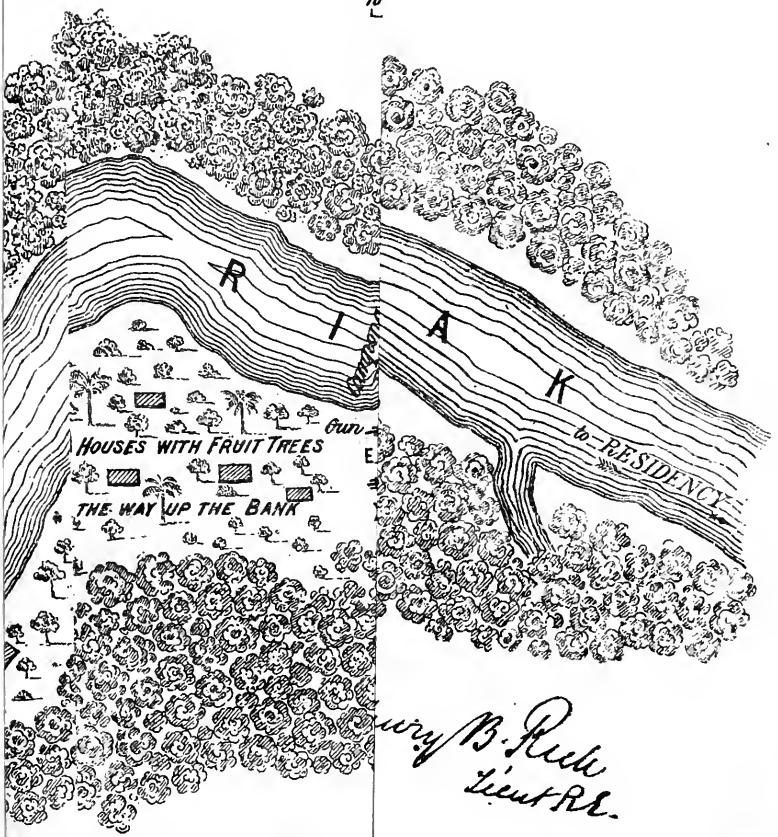

Salawa R.



Note "Malacca", where the other disturbance in "Singhie Ujong" prevails is S.E. of "Perak".

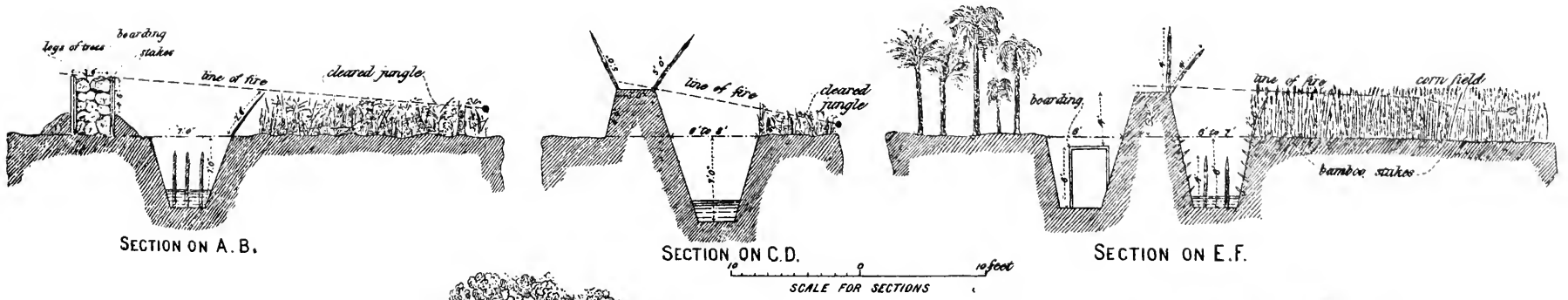
SKETCH OF STOCKADES AT "

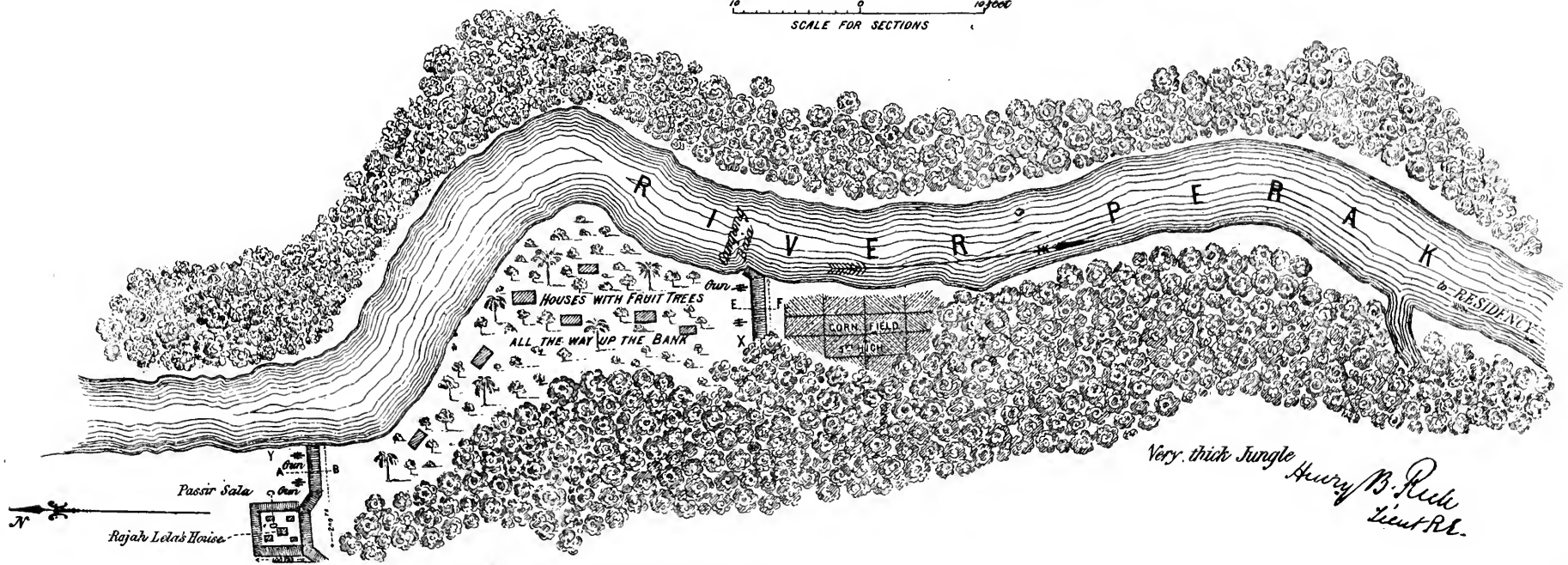


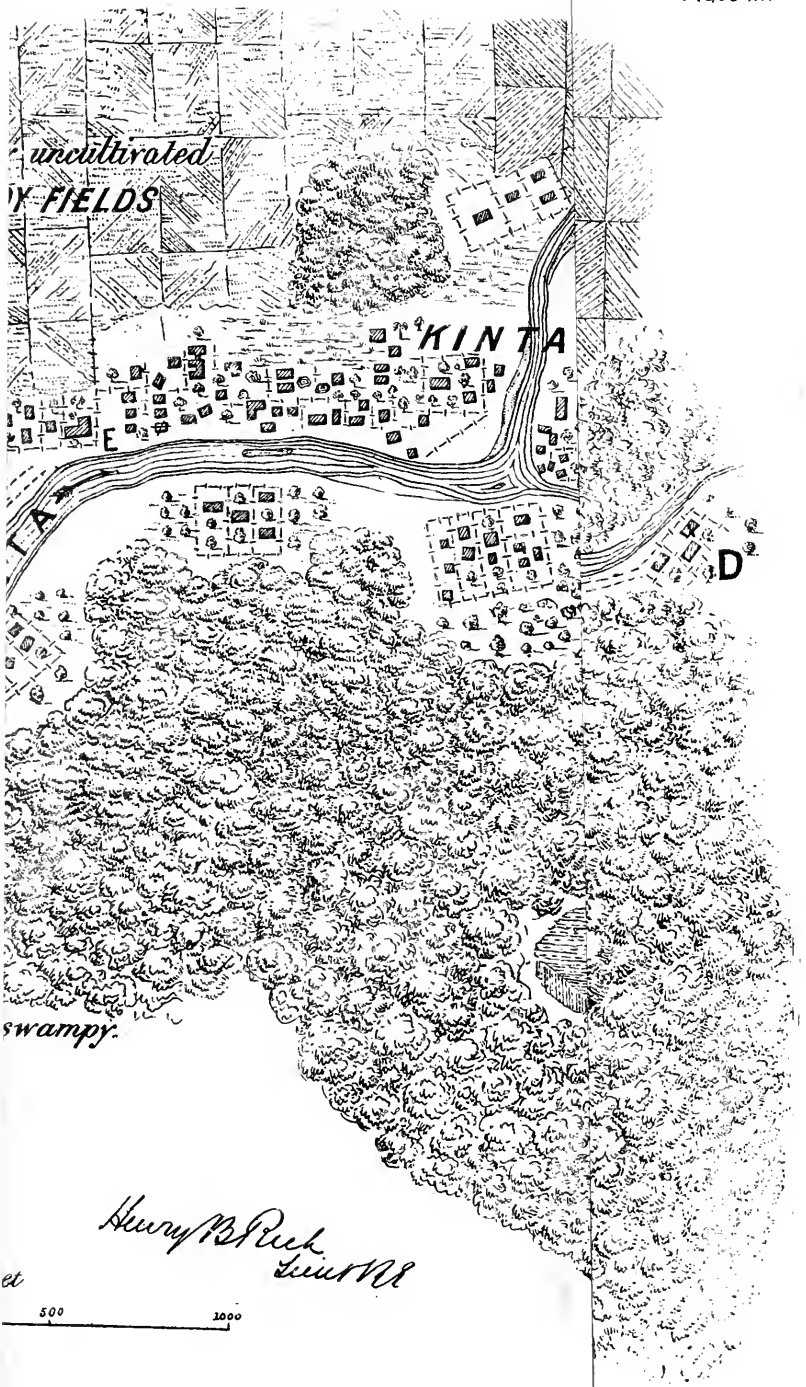


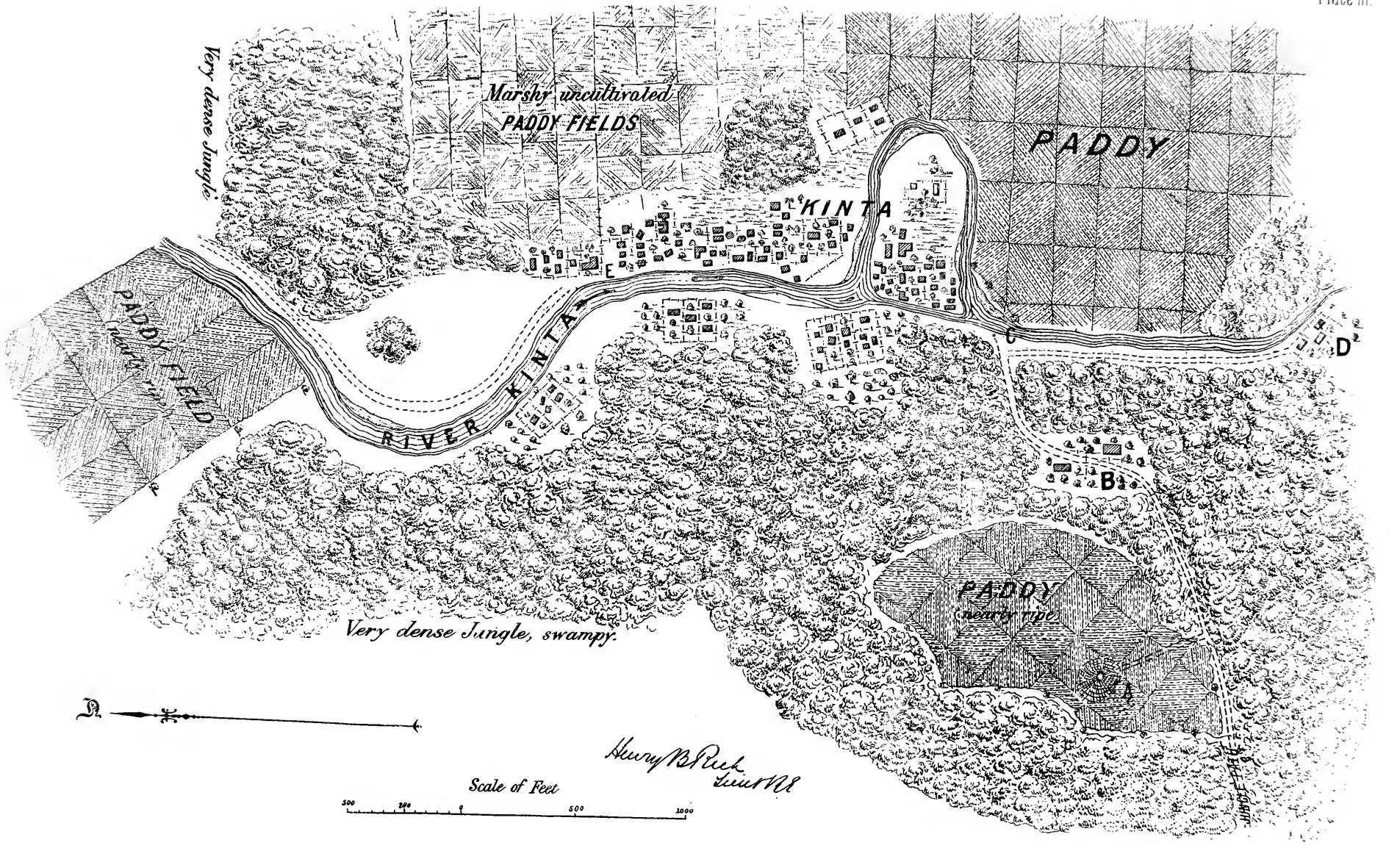
Henry B. Rule
Lieut RE.

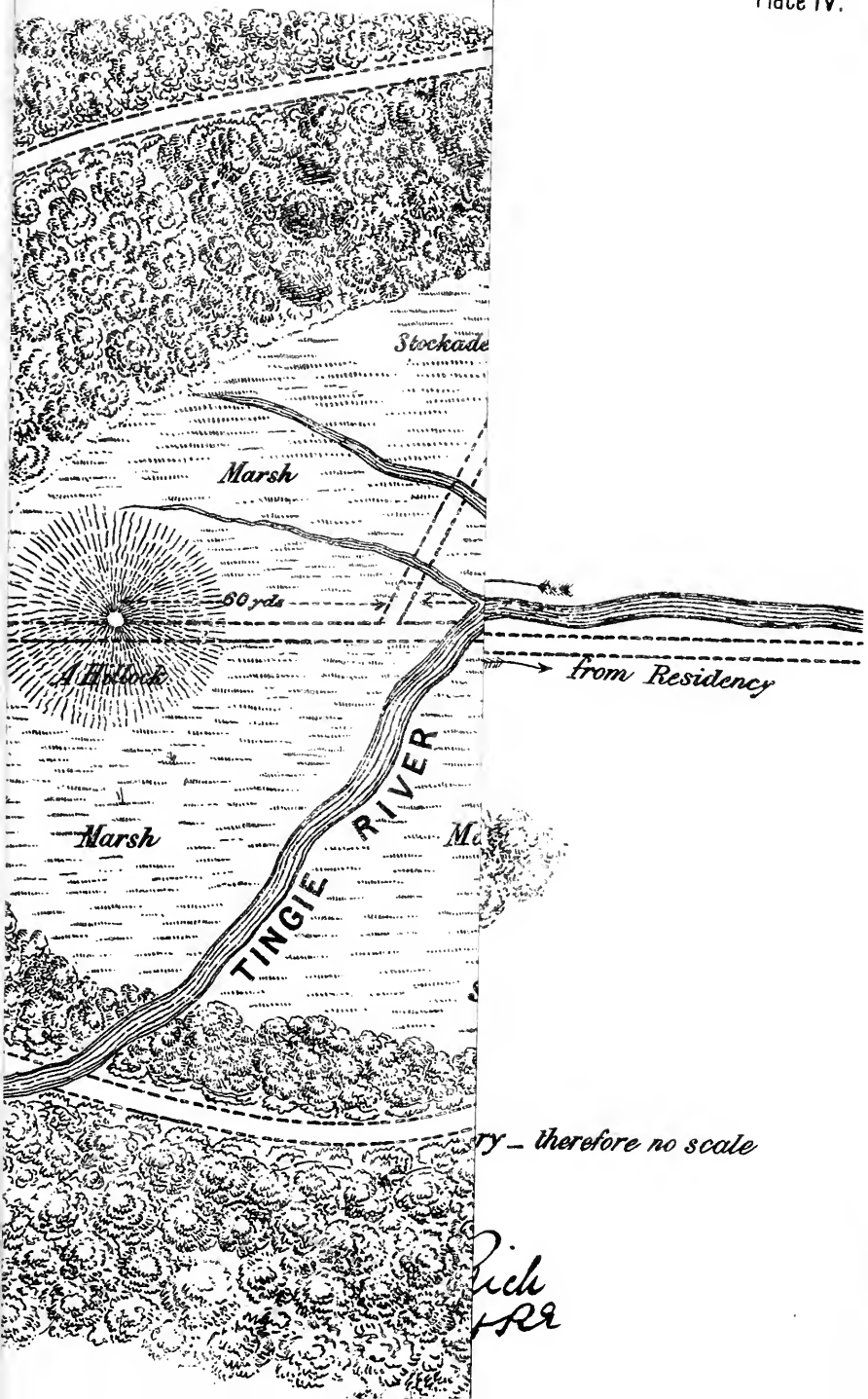
Sketch of Stockades at "Campong Baia" and "Passir Sala".

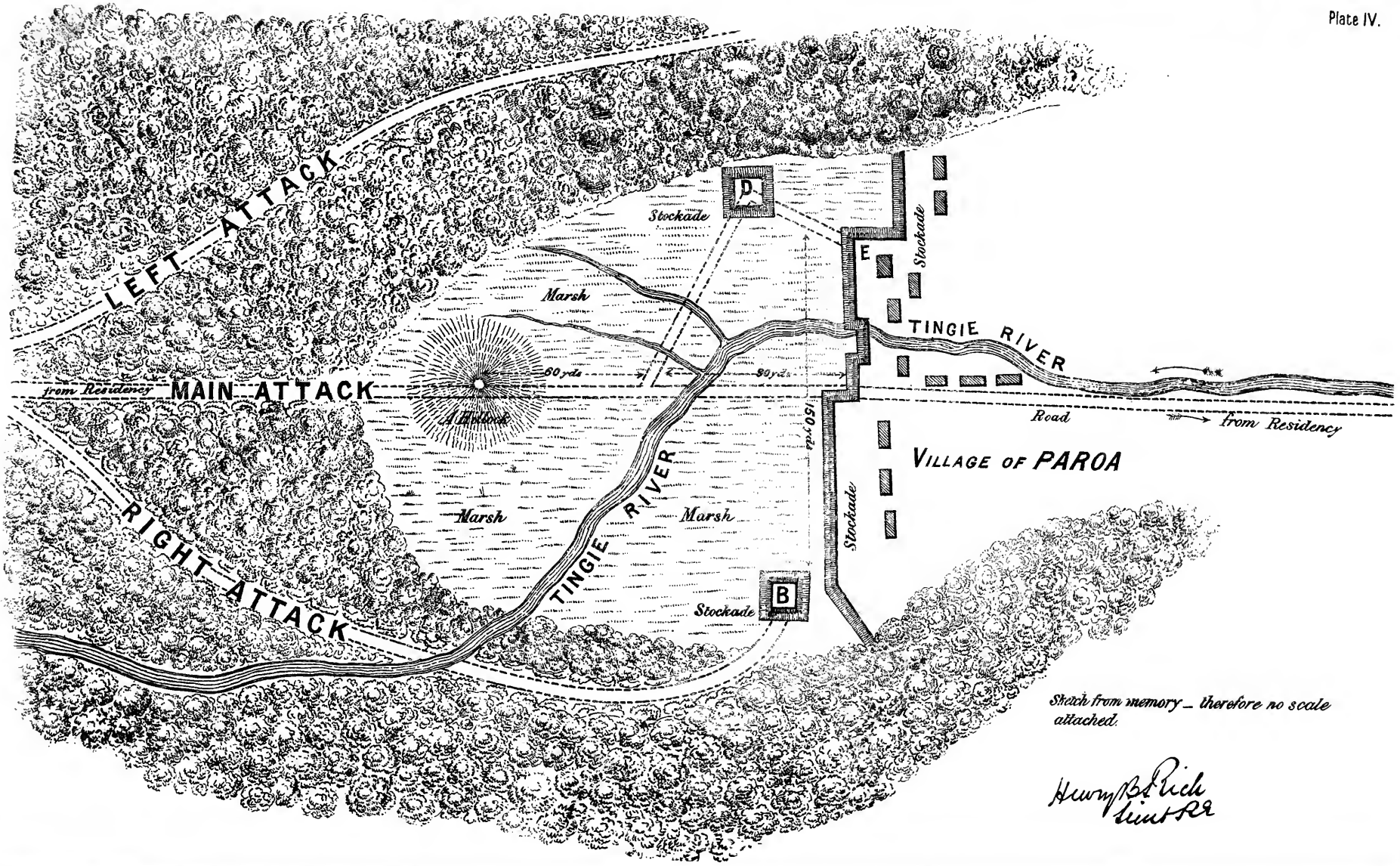





uncultivated
FIELDS
KINTA
swampy.
Henry B Beck
Lieut RE
500
1000


Very dense Jungle
Marshy uncultivated
PADDY FIELDS
PADDY
KINTA
E
PADDY FIELD
RIVER KINTA
C
D
B
PADDY
(nearly ripe)
A
Very dense Jungle, swampy.
Henry B Ruck
Lieut RE
Scale of Feet
500
0
500
1000


Stockade
Marsh
60 yds
A Hillock
from Residency
TINGIE RIVER
Marsh
Ma
ry – therefore no scale



Sketch from memory – therefore no scale attached.

Henry B. Rich
Lieut RE

ON FIELD WORKS FROM A TACTICAL POINT OF VIEW.

CHATHAM, 6th SEPTEMBER, 1876.

After some introductory remarks Lt.-Colonel Schaw proceeded to observe that his object in this lecture was to view Field Works with the eye of the tactician, rather than that of the Engineer—and wherein consists the difference? Mainly in this—that in tactics the *troops* are the primary consideration, the central point on which our attention must be fixed. In Engineering we have to consider the *material means* which will aid the troops in carrying out some particular operation. And it no doubt is too often the case that the Engineer is inclined to put his works in the first place, and to forget that apart from the troops they are but a dead body without the animating spirit. To avoid such a mistake we should endeavour in all cases before attempting to design fieldworks to grasp thoroughly the circumstances under which they are to be used, the numbers, composition and character of the troops that are to defend them, the numbers and description of the hostile forces, and the direction of their approach; the object of the fight —whether merely to gain time and then to retreat, or to fight a defensive offensive battle with the object of beating the enemy, or if more purely defensive tactics are intended, as to hold certain positions to prevent the enemy from passing, and in this case whether it is essential to prevent the enemy from gaining certain vantage points from which he could effect his object by Artillery fire, as in Bridge heads, entrenched camps, &c., or whether a more elastic system of defence will answer the purpose, as in investing lines.

The time also and means available for the work must be known, before a decision can be arrived at as to the character of the works to be employed.

The *object of the fight* must be continually before the mind of an officer charged with making arrangements for the defence of a position. Clausewitz and other German writers insist very strongly on the essential difference between the defence of a *place* where the primary object is to hold a certain spot of ground and a *defensive position* taken up with the primary object of beating the enemy in a decisive battle—and this distinction is of great importance. Yet in the immense variety of circumstances which occur in war we constantly find that the special characteristics of these widely different cases merge insensibly one into the other, approaching more nearly to the former as the defenders are weaker, more nearly to the latter as they are stronger compared with their adversary. And here I must endeavour to remove a misconception which my friend Major Hale shows me has arisen in regard to a paragraph in my little book on the defence and attack of positions. I state that the general idea of a good modern position corresponds very much with that created artificially in a good modern fortress. By this I have been misunderstood to mean that a position is in all points like a fortress, which was far from my intention. The analogy only exists in the dispositions to be made for using to advantage the weapons of the defenders and securing them from those of the assailants. This is the object of taking up a defensive position and the more nearly you can approximate to the perfected arrangements of a fortress the better your position will be—always bearing in mind the object of the fight. If this be to beat the enemy then full liberty of offensive movement must be reserved—if it be merely to hold your ground then by all means imitate the front of a fortress as closely as you can.

In my little book I have endeavoured to explain my views with regard to those hasty defences which can be extemporised on the field of battle. Captain Fraser's prize essay of last year has also dealt ably with the same subject. It will therefore be unnecessary for me to enter at length on a discussion of it. I would only remind you of a few of the tactical principles involved.

First by whom are the field works to be made—a most important question to which an answer has only been given by authority within the last year, in an order with reference to the Autumn Manœuvres of 1875 which was drawn up by Col. Cooke, C.R.E., at Aldershot under the direction of Sir T. Steele the General Officer in Command at that station and approved by H.R.H. the Field Marshal Commanding-in-Chief. The proportion of entrenching tools to be carried by each battalion of Infantry, Regt. of Cavalry, and Battery of Artillery is now also fixed by General Order. The mode of transport is by a 2-horse cart for Infantry and Cavalry and on the limbers and wagons for the Artillery. The Pioneers of Infantry and Cavalry carry their tools and materials themselves.

With these tools Infantry are expected to prepare their own positions and Artillery their own emplacements after the general line to be taken up, and the portion to be defended by each Division, Brigade, Battalion and Battery has been fixed by the General Commanding through the descending scale of authority. To the Commanding Royal Engineer is given the responsibility of ensuring that the various parts of the line fit one another and form a harmonious whole in accordance with the instructions communicated to him by the General Commanding as to the character of the fight. The aid of the Engineers will be required in such technical works as the demolition, or construction of bridges, and the fortification of localities in the front line and in clearing the foreground, a duty which notwithstanding its acknowledged importance has not yet been assigned to any one in particular, or in improving communications within the position. To them also is assigned the duty of preparing a second line, consisting of redoubts, defensible localities or trenches as the case may be.

Probably it is within the recollection of some present that in 1874 I raised a discussion in the *Army & Navy Gazette* on the subject of the proper chain of responsibility and action in entrenching positions, with the immediate object of eliciting the views of Infantry Officers—in this I failed, for the discussion was chiefly carried on by Engineer Officers, but the indirect result has been

the order above alluded to, which although it does not quite accord with the views expressed by some of those who took part in the discussion must be regarded as a great gain and a step in the right direction, to be followed probably in course of time by improvements suggested by the peace manœuvres.

In the course of the discussion written or verbal in which I took part at the time it became evident to me, that there were two dangers to be guarded against, one which possibly I had not sufficiently recognised at first is lest able officers of Infantry who have studied their profession, and of whom there is a yearly increasing number, should feel aggrieved at being in a manner placed under the orders of junior officers of Engineers in the execution of works of defence. To avoid this difficulty it is clearly best that Infantry officers should as far as possible be given independent powers of action in this matter, but with these powers it is essential that they should also be trained to use them properly. For there is another danger which is the more palpable and evident of the two, namely, that a great proportion of the men and many officers of Infantry regiments dislike pick and shovel work and would rather have nothing to do with it. Until this dislike has been overcome and the use of entrenching tools has become as familiar to the Infantry as the use of their rifles, it will often fall to the lot of Engineer officers of junior rank to assume considerable responsibility, and to use great tact and judgment in order to avoid in any way wounding the sensibilities of Infantry officers while they aid them in preparing their positions for defence. The only key to right action in the matter is to bear in mind that each arm of the service is incomplete without the aid of the others, and that success in war can only be obtained by the harmonious working together of the different branches, each giving honour to the other, and striving to aid the other in the common object of gaining the victory over the enemy.

I believe I am not in any way betraying confidence in mentioning that I have lately seen the report of a Committee appointed to consider the question of Cavalry Pioneers and the decision of H.R.H. in the matter, the point which chiefly interests us as a

Corps being that Cavalry Pioneers are to be prepared to destroy telegraphs and railway tracks and to construct trestle bridges; but that all important demolitions and reconstructions are to be performed by Royal Engineers. The Committee consequently recommend that a sufficient proportion of Engineers be given a proper equipment to render them capable of rapid movement with bodies of Cavalry carrying with them the necessary tools and materials. Here is a future for active and enterprising young officers of Engineers on which they are much to be congratulated.

So far then for the distribution of labour in the hasty defence of a position. If the question be not completely set at rest, it is at least so far settled that there can be but very little difficulty in commencing operations. The onus of the preparation of the main line of defence now rests on the Infantry, not on the Engineers whose part in the work is not so clearly defined, but must be determined by circumstances according to the wishes of the General.

The *character of the work* to be performed in an enclosed country, such as the greater part of England, will be chiefly clearing a range for the fire arms of the defenders. Fences generally give ready made cover, requiring but little improvement, a piece of shelter trench to supplement existing cover, may here and there be required; but the provision of cover for the defenders is generally of far less importance than the removal of cover which would aid the enemy in his attack. When such cover comes near the position an obstacle must be created and direct and flanking fire brought to bear on it.

In perfectly open country so frequently met with on the continent of Europe, and occasionally even in England the preparation of cover is, on the other hand, of first importance, and where it has to be made it must not be forgotten that a shelter trench is a serious obstacle to the movements of artillery, and will break the formation of cavalry, therefore sufficient spaces must be left for the movements of these arms. One hundred yards will allow a Field Battery to move out deployed in line. Two hundred to two hundred and fifty yards is required for a regiment of cavalry. A battalion of infantry in the new attacking formation, does not need

more than about three hundred yards and when obstacles are made in front of a position this will be the minimum opening if offensive action be intended. For an Infantry Brigade of three Battalions, one being in reserve about 600 yards would suffice. The general idea of what is required in the main position is a shooting line as nearly straight as the features of the ground will allow. The echelons which must be made where spurs run out, or valleys intersect the line will generally afford the necessary openings for offensive action, and to avoid danger to the advanced echelons from the fire of their comrades in rear, the trenches should not overlap, but such openings be left that fire directed at least 30° off the perpendicular from the rear trenches will pass clear of those in front. In rear of the shooting line, and as close to it as possible, cover is needed for the supports in any convenient formation, their object being solely to fill gaps in the front line. The local or special reserves are from 100 to 600 yards in rear of these again at suitable points, consisting generally of whole or half battalions to act offensively (outside the position if the opportunity offers), to drive out an enemy who may have broken through the line, or in course of time to be absorbed in the front line.

The artillery partly defending the approaches to the position, partly massed so as to be moved rapidly to meet the enemy's artillery on the positions which it can be foreseen it must occupy.

As regards the alignment of the artillery, whether in front line or second line, much will depend on the features of the ground. If the ground be nearly level, or gently sloping to the front, it may be necessary to place artillery in front line or only slightly retired and without any infantry in front of the guns. In such a case the guns can defend their own front as long as they are not silenced by the enemy's artillery, but then a gap is left in the line which must be filled by infantry kept in reserve; the arrangement is however very inconvenient for other reasons. The guns of the defence must be able to meet those of the attack whenever they appear. This evidently is very difficult to manage if they must be removed from one part of the infantry line and thrust into another. In any case, if the ground immediately in front of the guns affords

cover for hostile skirmishers, infantry must occupy it to keep the enemy's skirmishers at a distance. Frequently the best artillery tactics in defence, when the defending artillery is comparatively weak, will be to decline an artillery duel at first, and to reserve the guns to crush an infantry attack. In such a case the position in front line would be extremely inconvenient. Hence it is in every way best if there be higher ground in rear of the infantry line on which the artillery can be manœuvred. In attack, guns may frequently be in front line if the ground be open and the flanks secured; they defend their own front against counter attack, and for them efficient fire is *first*, security *second*, besides their infantry are pushing on and will soon be in front.

It will sometimes happen that engineers may have to prepare positions for an army beforehand. In this case tactical knowledge is of the utmost importance and a complete accord between the troops who fortify, and those who defend is absolutely essential. The battle field of Sadowa is an example of a want of such accord and of the failure which resulted from it, although in detail the works constructed were exceedingly good. The battle field of the Lisaine on the other hand is an example of perfect accord between all branches of the army, with most successful results. To go farther back in Military History the lines of Torres Vedras give us a still more notable and complete example of a thoroughly prepared position, into which an army retired and securely held the pursuing enemy at bay, until reinforcements enabled its great commander to issue forth once more, and carry his victorious army into the capital of his former assailant. We must note that in these two successful cases, the commanders were most able men who by their knowledge and energy ensured the harmonious working of the different departments of their armies, and in the case of Torres Vedras we know that the engineers who carried out the work, were men of very superior ability and energy, and were in constant and direct communication with the Commander-in-Chief, more particularly Colonel Fletcher, of whom I believe there is a good prospect that before long we may have an authentic portrait in this Institute. At the Lisaine only a few days were available for preparation and we find that no enclosed works were attempted. At Torres Vedras

nearly a year was employed in preparing the triple line of enclosed works, which the forethought and genius of Wellington conceived, and the professional skill of Colonel Fletcher and the Engineer Officers under him so happily carried out.

Sir John Jones' admirable chapter headed "Observations on lines and retrenched positions generally" which forms part of his memoranda, relative to the lines of Torres Vedras, and is now bound up with the "Journals of Sieges in Spain," although originally written some 60 years ago, before breech loaders or rifled guns were thought of, forms still a most valuable study for every officer of Engineers. It is in fact an essay on "Field Works from a Tactical point of view," and it is only in so far as tactics have altered with changes in fire arms since that time, that the maxims and views so lucidly and authoritatively put forward by Sir John Jones, have become in any degree obsolete.

It may be well briefly to review that chapter, and to note the few points of difference which have become necessary in the tactics and correspondingly in the fortifications of the present day.

In the earlier pages of the chapter, Sir John Jones argues from Wellington's successes and the necessities of our country, which, then as now, could not attempt to cope in point of numbers with continental armies, that defensive battles may be successful, and that they must often be fought by us. He then deduces mainly from the incidents of the battle of Waterloo, that strong defensive points should be fortified and held in *advance* of the line of battle, "either with the view of covering a weak front by an advanced or flanking fire, or of preventing an assailant from establishing his artillery on points favorable for cannonading the defensive line previous to using the bayonet."

Where existing localities do not offer these desirable tactical points Sir John Jones recommends the construction of flanked works, or two or more or a system of redoubts flanking one another.

He notes however two difficulties which must always be found in entrenching positions, first the want of time to make strong works after an army has taken up its position and a battle becomes inevitable; secondly that "it is scarcely possible in any moderately

open country to select a position to be fortified in advance for the protection of a frontier or a capital which an enemy will not find roads to turn and render useless."

The points to be noted in Sir John Jones' memoranda are first the question of defensive versus offensive battles. His common sense view of this much vexed subject remains as true in our day as it was in his. Of two opposing armies that which deems itself the stronger from any cause attacks The moral and strategical advantages of the attack are as great now as ever, and history is full of examples which show the great probabilities of success which belong to an attack carried out with full energy and determination; but the weaker force, acting on the defensive, if animated by true courage and discipline and directed with skill *may* succeed and often *has* succeeded in not only parrying the blow of its adversary, but in so following up this success as to complete his overthrow. In our wars with uncivilized nations our "role" is almost invariably to attack and "*toujours l'audace*" is our motto. Superior intelligence, discipline, and weapons, and the natural determination of our race, justify us in such cases in attacking an enemy vastly our superior in mere numbers, and victory has almost always been the result. In a contest with a civilised enemy however, we must often be content, owing to our comparatively small numbers, to play the slower game of fighting on the defensive and biding our time for the effective return blow which may decide the war in our favour.

Next comes the question of advanced posts or advanced positions and this is so important as regards the tactical use of field works that it must engage our attention for a few minutes. Many modern writers insist on the occupation of an advanced position about a mile in front of the main position in all cases, in order to oblige the enemy to show his hand in forcing his way through this outer line and so to commit himself to a particular line of attack without any previous reconnaissance while enabling the commander of the defending force to make his arrangements accordingly. Others maintain that this advanced position is disadvantageous because either the troops defending it must retreat, and in retreating must suffer a heavy loss, and with this retreat and loss will result dis-

couragement to the defending army, or else the commander may be drawn into a fight in advance of his selected position by sending reinforcements to aid in drawing off the advanced guard. This is the view taken by Colonel Hamley who advocates the use of outposts only as a screen to check reconnaissances by cavalry or small bodies of infantry and to guard the army against surprise. He would place them two or three miles in advance of the troops they guard and their function is merely to delay an attack, falling back regularly when pressed. The Germans as a rule use at first strong advanced guards on the main roads approaching the position to be occupied by an army acting on the defensive, these advanced guards throwing out their own outposts to protect their own positions and falling back only when very strongly pressed. General Von Werder's arrangements previous to the battle of the Lisaine are an excellent example of the use of this method. The advanced guards on the roads leading through Montbeliard and Hericourt to Belfort were at first five or six miles west of the Lisaine. At Arcy, St. Marie, and Aibre were four battalions, two squadrons and two batteries, and at Chavanne, and Villers Sur Saulnot on their right $2\frac{1}{4}$ battalions 1 squadron and 1 battery. Altogether on a front of about 4 miles, and 6 miles in advance of the main position, and covering the approaches to it $6\frac{1}{4}$ battalions or 5000 infantry with 3 batteries and 3 squadrons. They were ordered to hold their ground until the enemy showed his full force and then to retire. They were attacked on the 13th January and fought a delaying action gradually retreating on the main position which they reached in the evening in good order having lost 9 officers and 249 men—some badly wounded men had to be left behind. On the extreme right of the German position the advanced guards had not been attacked, hence it was evident that the French would make their first general attack between Montbeliard and Hericourt and the troops were disposed accordingly to meet this attack, which they did successfully. No fortifications were used in this case in the position of the advanced guards, which were at an extreme distance from the main position. The mode of fortifying the positions of advanced guards however is clearly laid down in Wagner's principles

of Fortification; no enclosed works are to be made, only such as will resist a front attack and allow the defenders to move out easily when turned.

The advanced works advocated by Sir J. Jones, however, are much nearer to the position and are intended to form an integral portion of it and to act at the same time with it. His types are Hougoumont and La Haye Sainte, the former 400 yards in front of the right the latter 300 yards in front of the centre of the main position, the interval between them being 1,300 yards. Of the two objects he assigns for such advanced posts viz. flanking the front and keeping the enemy's artillery at a distance, the latter is evidently now obsolete, to fulfill it any measure the advanced posts must now be at least a mile in front of the position in fact they would form the advanced guard position advocated by the school whose principal exponent is Captain Popp of the Bavarian Engineers.

We shall only be able to form a correct judgment as to this question of advanced posts when we consider each particular case by itself with all its conditions. For instance in the investment of a fortress an advanced guard position is generally necessary, because the outposts cannot be pushed very far in advance of the main position which should itself be as near to the fortress as its artillery will permit. Hence to secure the main body from surprise by sorties and to give them the necessary repose the outpost line must be stronger than usual and fortified with care.

Again in those parts of an ordinary defensive position where the country in front is open and clearly seen for some miles from the position an advanced guard position would, probably, be not only useless but hurtful; because it would not impede the enemy's view of the main position, and the retreat from the advanced position to the main position would certainly be attended with heavy loss and if closely followed up by the assailant might give him great advantage, as it probably would save him from much of the fire from the main position which could not be directed on him without endangering also the retreating advanced guard. On the other hand if in front of part of a ridge held as the main position of an army were found an inferior height which would afford good positions for the

enemy's artillery or cover the assembly of his infantry it might be of great importance to hold it by a strong advanced guard of which the ultimate retreat would be comparatively safe, across the valley covered by artillery from the heights in rear and probably also by infantry fire from the defenders established on the reverse slope of the advanced ridge. The advanced ground so occupied would mask the main position and so deceive the enemy for a considerable time as to its real nature. Such partial advanced positions give also great facilities for counter attack, and as I have endeavoured to show in my book they often form one of the best means of parrying the turning of a flank which is now the ordinary tactics of the attack owing to the very great difficulty of carrying a position in front.

Under the ordinary conditions of a good defensive position a simple system of outposts which will guard against surprise and delay the enemy's approach, may answer every purpose and the attempt to make a determined stand with a comparatively weak force on disadvantageous ground at some distance in front of the main position would only serve to discourage the defenders and encourage the enemy by his easy victory. We see then that it appears impossible to lay down an absolute rule as regards advanced guard or outpost positions. Their distance from the main position, their extent, the degree of tenacity with which they should be held and their consequent strength in defenders and fortifications or whether any such positions are required at all are all dependent on the ever varying circumstances of war. But as a general rule we may consider that Field Works will only be required in an outpost line when the opposing forces are in comparatively stationary positions and so near to each other that exceptionally strong outposts are necessary to secure the main body from surprise; such would be the case in investments or in the attack and defence of such extensive positions as the late wars in America or in Spain or Servia have made us familiar with.

The Horse Guards order dated 17th July 1876 as far as it refers to the defence of positions gives only general principles; a line of outposts, main body of defenders not deployed until the attack is developed, strong reserves, and counter attacks. But the general idea is that the outposts must be strong enough to make an enemy

show his hand. When the position can only be approached by a few roads this is comparatively easy as each road forms a defile which can be strongly defended by few troops but when the country is all open and passable by troops, or when it is intersected by a multiplicity of roads as in England the task becomes much more difficult.

With regard to advanced posts under the close fire of the main position; the range of firearms having increased materially their distance from the position and from one another may evidently be increased proportionately. As examples of such advanced posts in the late Franco-German war we may notice those held in front of the German position at the Lisaine which proved of immense value to the defence. At Mont-beliard the old castle, so massively built as to be little damaged by Field Artillery, was held as a bridge head covering the passages of the stream and flanking it towards Bethoncourt; it was armed with six heavy guns,and garrisoned by half a battalion. They were surrounded by the French in the town and cut off from the main body for two days; but being well provisioned and supplied with ammunition they held out and fulfilled their object, until relieved on the retreat of the French. At Hericourt a small wooded hill "Mougnot" west of the town and the river was fortified with trenches and abatis and was held by one battalion throughout the whole engagement, against repeated attacks. It was 500 or 600 yards beyond the river and nearly a mile in advance of the batteries which supported it. Had it not been held, it would have been very valuable to the French, as a stepping stone and place of assembly for the assault on Hericourt.

In these cases trenches and abatis or strong buildings took the place of redoubts, their distance in front of the position was considerable and their garrisons were strong in proportion.

The mode of creating such strong points suggested by Sir John Jones is impossible in the present day. It is now pretty generally admitted that enclosed works to be tenable against the attack of modern artillery must be well provided with bomb-proof cover, and

we all know that a redoubt in any degree secure against a rush and with sufficient bomb-proofs to shelter its garrison from the 3 or 4 hours bombardment they may expect as a preliminary to the infantry attack is not a work to be extemporised rapidly. The collection, preparation, and transport of the necessary timber is in itself a considerable work and the time required for the construction of the redoubt can in no way be reduced to less than about 3 days. It is the terrific effect of artillery fire on men in a confined space that has thus diminished the use of redoubts in modern warfare on account of the great labour required to secure their garrisons from its effects; while at the same time the equally destructive effect of direct infantry fire has given to simple lines of trench a defensive value they never had before.

Although advanced posts 400 yards in front of the main line would not now have any direct influence in most cases in preventing the enemy from "establishing his artillery on points favourable for cannonading it," because his guns may be placed at a mile, or two miles, or even more from the position,—yet such posts may still have great value, as for instance the farmstead of Moscou at the battle of Gravelotte, commanding as it did by close musketry fire the defile by which the German guns and horse must needs pass to gain the French position. It is true that the defile was also commanded by the French artillery; but when they were silenced by the superior German artillery the farmstead still sealed the pass and it was only by the most heroic exertion and with very heavy loss that at length the Germans succeeded in wresting its possession from their foes.

To return however to the question of entrenched positions. Sir John Jones places his redoubts in, or in advance of the main line. Is this the best position for them, or is it better that they should be in second line? In my judgment if made at all, they should generally be in the main line. For what is the meaning and intention of a redoubt?—it is an enclosed secure position for fire arms in the hands or infantry, or artillery, or both, from which they may continue to fire *after* an enemy has passed them; if in the main line or in advance

of it they check the further advance of an enemy and aid the troops in the open in recovering their lost ground, both by the fire they deliver on the flanks of the enemy and also by the moral influence they exert on the troops who have lost ground, who naturally desire to relieve their comrades temporarily surrounded, and also feel feel that they have a very material aid in the fire these comrades continue to deliver on the flanks of the enemy. On the other hand if the redoubts be in the second line their peculiar value of being able to continue their fire after they are surrounded by the enemy does not come into play until the second line is lost—and the chances of recovering a second line after both first and second are lost is evidently small. It no doubt is true that a redoubt captured is a strong point for the enemy and that it is a target for his artillery fire; but to my mind this is only an argument for making redoubts, if made at all, so strong that they are very difficult to capture or silence. On this point Sir John Jones tells us that the experience gained in the Peninsula shows that an unflanked work of even more than ordinary field profile if skilfully and determinedly assaulted will generally be carried, and he instances redoubt Renaud, forts Picurina and Napoleon. We have no good modern example but the concentric attack of swarms of skirmishers succeeding a bombardment would seem to make the defence of the redoubt at least as difficult now as formerly.

How then can we make redoubts secure against assault? Will arming them with artillery give them additional security? Many examples decide this in the negative but I will select one from the experience of the late American war.

This is briefly General Sherman's account of the capture of Fort McAllister. On his arrival at Savannah after his famous march, about the 19th December 1864, he found the city fortified and able to stand a siege. It was therefore necessary at once to open a communication with the fleet which was believed to be in Ossabaw Sound at the mouth of the Ogeechee river. This river was closed by Fort McAllister armed with a numerous and powerful artillery and having a garrison of 250 men. The fort was an earthwork, the land front having a bastion trace, with a good profile, palisades

in the ditch, and abatis and land torpedoes on the glacis—the forest cleared for some distance round it. To get at the fort which was on the right bank of the Ogeechee it was necessary to restore King's bridge, carrying the railway from the south-west into Savannah, which had been destroyed by the Confederates. The Engineers of the 15th Corps were united to carry out this repair protected by General Haynes' division of Infantry, about 4000 strong without any artillery. This division then crossed the bridge and marched down the far bank of the river to the Fort. The assault was delivered from three sides at once. Each attack was made by infantry in line formation covered by skirmishers who ran on in front and lay down behind logs, which unfortunately for the Confederates they had omitted to burn or remove after felling the trees and using the boughs for abatis. The skirmishers shot many of the gunners who worked their guns *en barbette*. The stormers pushed boldly in through the torpedoes, abatis, palisades, and ditch and in about a quarter of an hour the fort was won. The attack only lost 92 men, a large proportion of whom were killed or injured by the torpedoes. The defence lost 50 in killed or wounded. The moral of the story is that a field fort unflanked and unsupported although armed with artillery and well provided with obstacles can be run into by determined infantry if the attack be made with sufficient numbers. Probably the losses would have been much greater if the distant approach of the attacking force had not been covered by woods, and if the defenders had not left logs on the cleared ground—possibly even it might have been necessary in such a case to defer the attack until dusk.

Another mode of strengthening a field work is to provide inside it a keep or reduit, and in passing let me notice that this French word "*reduit*" (which has been adopted by the Germans in the same sense) was mistranslated "*redoubt*" by some of our earliest writers on Fortification, and thus we have in our Woolwich text book the strange misnomers of the *Redoubt of the Ravelin*, the *redoubt of the re-entering place of arms* and so forth, the works not being redoubts at all but open at the gorge. The word *reduit* is equivalent to our Keep or Retrenchment, *redoute* to our redoubt.

First we must consider the tactical use of a keep. Its object is not for the garrison of the outer line to retreat into, but in order that the whole work may not be lost in case the enemy gains an entrance at some point; the fire from the keep which ought to sweep the whole of the interior preventing him from occupying it. To fulfil this object the keep must be so constructed that it may not be injured by the preliminary bombardment, and that at the time of the assault it may be secure against a rush. I am not aware that any feasible project for combining these advantages in a Field-work has ever been brought forward. In fact in none of our permanent works that I have visited is there a keep fulfilling these conditions. The only good example I have seen is in the detached forts at Antwerp. But let us endeavour to realize the tactics of the attack and defence supposing a keep to exist in a redoubt. The question is most fully worked out in Wagner's "Grundriss der Fortifikation," the excellent text book used in the German war schools which I have just translated with the partial aid of Lieut. Pilkington, and which will shortly be accessible to all R.E. officers through the energy and *esprit de Corps* of Col. Lennox, who is publishing it as one of his series of translations. We must suppose the assailants to have got in to the ditch, spread out in it, and ascended the escarp, and exterior slope on a broad front. Their aim should be to drive the defenders of the parapet back on the keep and so to prevent the latter from firing and compel the surrender of the whole garrison. The defenders on the other hand try to retreat right and left of the keep to the gorge of the work, exposing the assailants to its fire, should the first effort of the inner reserve to expel the enemy by a volley and charge be unsuccessful. What becomes of the garrison of the outer work after they have lost the front parapet is the difficulty—retreat into the reduit is entirely inadmissable—Wagner says it is best if there be a place of assembly in rear of the reduit for the garrison to retreat into, and such a place of assembly he has designed in a permanent detached fort given in his Fortification Atlas, but except in very roomy works there would not be sufficient space. In Brialmont's Antwerp forts the *batteries basses* at the gorge would probably be used as such places of assembly. But some one may ask why not

retire into the keep? The answer is clear, because the enemy following close at the heels of the retreating garrison would go into the keep with them, as our troops did when they assaulted Fort Napoleon on the Tagus. The rule holds good in the defence of houses or villages. If the upper story of a house be held as a reduit it would be proper to remove the stairs and substitute a ladder; and should the enemy break in below, the garrison of the lower floor must be sacrificed and the defence continued from above. One must note however that such a mode of defence would only be possible when the building is exceptionally strong and uninflammable and not exposed to artillery fire; in the more usual case of buildings liable to be attacked by artillery or to be set on fire it would be useless to attempt to hold the upper floor as a reduit.

So also in the defence of a village, every effort should be made to maintain the first line, that on the outskirts of the houses consisting of enclosures of all sorts with any suitable buildings loopholed only on the outside. The second line should be arranged so that the reserves can move out readily to retake any part of the first line which may have been carried by the enemy. The tactics of the defence are generally *not* to retreat from line to line, but to use the second line as a barrier to the progress of the enemy and a starting point to retake the first line. There are cases however when the defence may with advantage be confined more strictly to the interior of the village, viz:—When the enemy's artillery can command the outer line; but when the extent of the village is such that an interior line can be defended, screened by the houses in front from distant artillery fire. The fierce struggle at Bazeilles which formed the most sanguinary episode of the battle of Sedan is a good example of such a case. It is noteworthy that the attempt to bring guns through the streets to attack the inner line at close quarters was shown to be excessively hazardous—in one case it was successful, but in another it failed, although the artillerymen sacrificed themselves most nobly to the last man; and this leads one to to the conclusion that when buildings are screened from distant artillery fire, and guns to attack them must be brought within close musketry range, the infantry in the building will probably succeed in beating off the guns.

But to return to the question whether a Field Redoubt can advantageously be strengthened by a reduit, I think the answer at present must be in the negative. The Düppel entrenchments are a warning that no timber blockhouses can be depended on against a well conducted artillery attack—an earth work is the only resource, and to be of any use it must have a deep ditch and a high command and will take up a great deal of room, and my own strong belief is that the same labour employed in enlarging and providing obstacles and flank defence for the outer ditch so as to keep the enemy outside altogether would be more profitably employed.

We may notice that the new German Forts at Strasburg have no reduits.

The question of the fortification of battle fields has been discussed at considerable length in the *Revue Militaire de l'Etranger*, Nos, 287, 26th Feb., and 293, 8th April, 1876, and the ideas of various writers Austrian, Prussian, Russian, and French compared. Amongst other points this one of enclosed works has been considered. The solution which seems to have been adopted in Russia and that proposed by the author of the Article seem to me almost equally defective, although the former is in some ways preferable.

The question of a really efficient Field redoubt is one which may well engage the attention of the Corps; at present we have no good type. The conditions to be fulfilled in my judgment are the following:—

1. A perimeter sufficient for a garrison of 2 to 4 companies and 4 to 6 guns or mitrailleuses to fire to the flanks—the direct fire of artillery should be from batteries or gun pits retired behind the line of redoubts, if circumstances of ground permit.
2. A parapet sufficiently thick to resist field artillery—variously estimated from 9 to 14 ft., and varying with the nature of the soil.
3. Such protection by traverses, parados, splinter proofs, &c., in the interior of the work as will secure the garrison from the preliminary bombardment and from the encircling fire of small arms. Hence a low parapet in rear is inadmissable unless there be a high parados.

4. The trace profile and accessory defences so devised that the redoubt may not be liable to be taken by a determined rush of infantry; but that its fire on all sides may be effective even when surrounded by the enemy.

5. Simplicity of construction, sufficient drainage, and the labor and time reduced to a minimum. 8 tasks for the garrison may be taken as a probable fair estimate of the time and labor required for constructing such a redoubt; by employing 3 reliefs of workmen the work might be completed in from $2\frac{1}{2}$ to 3 days under favourable conditions, exclusive of the labor of procuring the timber &c., required for the splinter proofs.

Whether it be possible to devise such a work I will not undertake to say; but unquestionably it is excessively difficult to fulfil modern requirements of defence in an enclosed work, and I should prefer myself not to attempt an enclosed redoubt unless a fortnight and ample labour and materials were available, so that a work of a semi-permanent nature might be constructed and this would only occur in positions intended for a prolonged defence and which can not be turned. For more hasty defences it seems necessary to use existing localities, buildings, woods and enclosures as the only possible redoubts for the field of battle.

While on the subject of redoubts however I would refer to a point much discussed at one time, viz: whether pairs of redoubts were preferable to single redoubts, that is whether the reciprocal support rendered by the redoubts one to the other was or was not superior to the stronger direct defence of one larger work. From a tactical point of view there can be little doubt but that concentration of defence in the one larger work is generally to be preferred to the division of the force into two bodies each liable to be the principal object of the enemy's attack, yet it frequently happens that the form of the ground renders such a division of the force if not necessary at least very tempting, and then it is an interesting question how far reciprocal defence may fairly be expected. A very good example is to be found in the history of the late American War.

After the capture of Atlanta the supply of Sherman's army depended on one railway which passed through hostile territory and which it was therefore necessary to guard carefully. Blockhouses, redoubts, and other defences were constructed to protect the bridges and intermediate depôts of provisions from raids of the Confederate Cavalry. Allatoona was an important point on the line, and the bridge at the river was protected by a timber blockhouse, while the railway station which lay 2 miles nearer Atlanta in a cutting and where a large depôt of provisions was formed was secured by two redoubts, one on each side of the cutting, flanking each other and looking down on the railroad station and stores. The fixed garrison of these two redoubts was 890 men—they were armed with artillery and were so near to one another that they supported one another both by musketry and artillery.

Hood worked round Sherman's flank to endeavour to cut his communications. He so far succeeded that he destroyed 8 miles of the line and threatened Allatoona detaching 4500 men with Field Artillery to attack the post.

Sherman learning his movements was able to reinforce the garrison of Allatoona by 1054 men bringing up the total to 1944.

The garrison endeavoured to make a stand outside the works but finding themselves greatly outnumbered they retreated in good order and defended the redoubts, which were vigorously assaulted several times without success. The last attack was concentrated on one of the redoubts; but was beaten off chiefly by the flanking fire from the other redoubt. The defenders lost 707 men, the assailants about 2000. The block house at the creek was set on fire by artillery and the garrison (85 men) was captured, but the arrival of northern reinforcements obliged the attackers to retreat. It is a remarkable evidence of the energy displayed by the Northern Commander that he at once set 10,000 men to work on the repair of the 8 miles of line and that in seven days it was again open for traffic.

The lessons however to be derived from the incident are:—1. That strong redoubts with large garrisons are able to afford reciprocal defence to one another, although small works with weak gar-

risons when strongly attacked may probably have quite enough to do to defend themselves. 2. That block houses are useless when liable to be attacked by artillery.

Another point of interest which merits our attention in connection with redoubts is the disposition of the garrison. It will be noted that in the fight at Allatoona the defenders in the first instance attempted to meet the enemy outside their works, but eventually retreated wholly within them.

Now considering the force of the garrison nearly 2000 men, it seems doubtful if they were right in doing so; although it would evidently be wrong to condemn them, seeing that they made a most gallant and successful defence, and we have no exact information as to the size of the works or the configuration of the ground; but generally speaking it is a principle clearly laid down in the German service, and which seems to be thoroughly judicious, that a field work should rarely be left to its own garrison as an isolated post; but should have an "outer reserve." When several works are constructed, supporting one another this would always be the case.

The outer reserve would consist of all arms and its duty is in the first place to furnish the outposts to guard against surprise, and when the attack takes place to aid the garrisons by fire on a more extended front, the troops being deployed between the works, and by counter attacks. The proportion between outer reserves and garrisons will vary; but as an average the former will be rather more than three times the latter, as regards infantry, with cavalry and field artillery in such proportions as the circumstances of the case may require.

The works then serve to protect the flanks of the troops in the open, while they in their turn prevent the works from being surrounded, and in some measure at least, protect them from being made the focus of concentrated fire. How far the outer reserves would themselves be covered by entrenchments will again depend on the circumstances of the case. The more purely passive, the fight is intended to be, the more will cover and obstacles be provided between the redoubts and *vice versa*.

A question frequently arises in defensive as in offensive warfare how to secure depots of provisions &c. by a small guard from a sudden attack. The long ranges of modern artillery, make this problem extremely difficult. There are only two ways in which it can be solved, viz.: by keeping the enemy at such a distance that his artillery fire cannot effectively reach the point to be protected, or by placing the stores under bomb proof cover. The first method generally involves the fortification of a very extensive position and its defence by a very large garrison. To be perfectly safe from even stray projectiles the enemy must be kept at 10,000 yards from the vulnerable point. For even moderate security he must not be allowed to come within 5000 yards, and allowing that the artillery mounted in the works will keep him at 2500 distance from it, the diameter of the circle enclosed must be about 5000 yards, or say 3 miles, to allow of some safe space in the interior. This gives about 9 miles of circumference, which would require an army corps for its defence even if well fortified. That this is not an over estimate will be evident from a glance at the map of the battle field of Sedan. We know that the whole of the interior of the French position was overwhelmed by the shells thrown by the German field batteries which were placed on the circumference of a circle whose diameter averaged 4 miles, and that in many places these batteries stood within a mile of the heavy guns of the fortress.—The German shells therefore only ranged 2 miles to reach the centre of the French position while our late experiments at Dartmoor have shown that 2½ miles is a range now commanded by *accurate* artillery fire if the target be visible. The example of Allatoona already referred to however is instructive as regards this question. The depot of provisions was formed in a railway cutting, and the two field forts on the opposite sides of the cutting commanded the railway in both directions and also swept by their fire the high ground through which the cutting passed. Here then is a case in which existing cover may be used with advantage, for a deep cutting gives great protection from field artillery, and takes the place in a great measure of the bomb proof cover which otherwise must be constructed. A railway cutting passing through a range of hills, particularly if there be a curve in

the line at this point may often be used to protect long ranges of sheds, containing army stores, from destruction by distant artillery fire, while field fortifications judiciously constructed and held by a few battalions with the aid of heavy artillery may secure the position from any sudden attack by an army in the field.

But it will be evident that unless advantage be taken of very marked local peculiarities of ground which secure a portion of the circumference both from close and distant attack, no entrenched camp can now be constructed with a diameter of less than three miles, and even with that extent there will be no real absolute security from the enemy's artillery fire in the interior. Should a portion of the circumference be secured by natural obstacles from the enemy's attack it must be remembered that the obstacles act both ways and render an investment of the position so much the easier for the enemy. On the whole then we may conclude that when it is desirable to secure a certain point from attack on all sides, if it be comparatively small (as a depôt of military stores) a permanent or semi-permanent fort, enclosing bomb proof stores, is the most economical and satisfactory mode of accomplishing the object; but if it be larger, as a double bridge head or an entrenched camp, a large enclosure becomes necessary from 3 to 5 miles in diameter, formed by detached works armed with artillery. If these forts be permanent or semi-permanent works secure against assault, then it will be sufficient to have a continuous line of flanked wall or other sufficient obstacle to secure the vital point from a night attack, and the garrison will consist of the necessary defenders of this inner line in addition to the garrisons of the forts. But if the detached works be only field works, it will be necessary to support them by outer reserves and in fact to form and defend a continuous line on the whole outer circumference.

Extensive forests or a mountainous character of the country may modify the application of these principles. Forests in particular limit very materially the power of artillery, while they give to the defence a great facility for extemporising a line of works practically impregnable if firmly held by even 2000 infantry, well supplied with ammunition, to every mile.

I have wandered through my subject in a somewhat desultory manner, conceiving that under the circumstances of the case attention to a rigidly logical discourse was hardly to be expected; but let me in conclusion sum up briefly what appear to me the principal points to be kept in mind, apart from technical details, in designing and carrying out Field works.

Field works properly so called are intended to aid troops acting on the defensive. The hasty works executed during a battle by an attacking army will not be taken into consideration. For an army in the field taking up a defensive position to receive battle the fortification of the main position is the principal object in most instances. The outpost line is not intended to offer serious resistance; but there are cases in which the defence of the outpost line is the primary consideration, as in investments, or when an advanced guard has been ordered to seize some point or position and hold it until reinforced by the main body. In an advanced guard position from which the troops are to retreat when outnumbered and outflanked, only the front defence need be considered; but in the fortification of a position where a decisive battle is to be fought the security of the flanks is the most important point. It is common to talk of constructing a redoubt to effect this object; but let us not be led away by our professional knowledge and technical instruction so far as to suppose that the fire from a redoubt will really protect the flank of an army. All the experience of the wars of the last few years goes to show that the tactical question on the battle field is, which side will invest or surround the other—the investor almost certainly wins the day from the overwhelming effect of his converging fire. Now the ordinary method of carrying out this encircling movement is for the assailant to attack all along the line held by the defender while he moves his reserves round one or both flanks, and so eventually surrounds the defender's position by a wide arc of fire. If he be so numerous and skilful as to succeed in completely surrounding the defender, as at Sedan or Metz, the catastrophe is inevitable; only a timely retreat or a skilful counter attack can preserve the defender from defeat when the enemy has got round his flank. It is evident that our supposed redoubt would

have but little influence on such a movement which would make it the focus of a concentrated fire, probably also enfilading our line. What we want to do is to prevent the enemy from marching round our flank or at least to delay his march as much as possible.

If there be defiles in prolongation of our line or in advance of it through which the enemy must pass to turn the position, those evidently are the points to hold. If they are naturally so situated that they cannot be themselves turned, they should be defended *à outrance*; but if they can be turned, a delaying fight is all that will be possible and a succession of positions must be prepared to be defended step by step by a strong advanced guard. Experience seems to show that when a considerable body of troops is forced to retire from a position, they cannot take up a fresh position to be strongly contested at a less distance than about a mile in rear of the first. Hence the first positions to secure a flank should be from 2 to 3 miles in advance of the general line, if they are to be used in this way. A strong battery slightly retired in echellon behind a flank may sometimes aid in securing that flank from attack, particularly if the country be very open; but it is very rare that a position can be found for such a battery where it cannot be met by a superior force of the enemy's artillery if they determine to mass their guns on that flank. As a rule then the flanks of defensive positions must be covered by advanced guards holding the roads by which they can be turned.

We must notice farther that the tendency of the attack is to stretch out the attacking line so as to envelope the defender. To meet this the defender generally stretches also, using material obstacles and fortifications as far as possible to aid him in holding the long line. But one side or the other will probably stretch too far, then comes the opportunity for him who has most men, or who has kept his reserves best in hand to make a strong attack on a weak part of the opposing line. This attack will be a frontal attack and if successful it may be extremely disastrous to the other side as it will divide their forces into two, one at least being driven away from its base; while when the flanks are turned the retreat may gradually be made in good order if commenced in time,

In the defence of positions we should never be satisfied with one string to our bow—An obstacle should always be *flanked*, but *direct* defence must not on that account be neglected; *artillery* fire should command all the approaches, but *infantry* fire must not be deemed a needless supplement to the more powerful projectiles—If the enemy have only one difficulty to overcome his task will be comparatively easy, and we must study to make it as difficult as possible.

There should be no cessation in our efforts to strengthen a position as long as the enemy gives us time. The incidents of the French Sortie from Metz on the 31st August, 1870, afford a valuable lesson on this head; they attacked the only portion of the investing line in which the troops had discontinued their labour of fortifying after the first day, on every other section of the investment the works were carried on without cessation; but from Failly to Colomby, little had been done for some unexplained reason and the result was that the French attack succeeded, and had it only been commenced and pushed on with proper vigour the results to the German army would have been very serious. In subsequent sorties against the German fortified positions the French never succeeded in passing the outpost line.

Should enclosed works be made let them give real security to their garrisons both from concentrated fire of artillery and also from a close infantry attack—a redoubt which does not fulfil these conditions is a mere trap for its unfortunate garrison if it be attacked with vigour, and we must always suppose that this will be the case.

Finally, when once war is declared let us never forget that the time has come for which all our previous training has prepared us, there must be no shrinking from responsibility, no false sentiment or misplaced regard for the interests of civil life. Everything must give way to the necessities of the military situation, and no qualms with regard to the future claims for compensation must deter from clearing away everything that would aid the enemy or interfere

with the movements of our own troops.—If buildings or villages come into the defensive zone the inhabitants must be removed without hesitation—a neglect of this may lead to a repetition of the terrible scenes enacted at Bazeilles.

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No. 3.

EXPLOSIVE AGENTS,

WITH SPECIAL REFERENCE TO THEIR APPLICATION TO INDUSTRIAL PURPOSES.

TO lecture to the Royal Engineers on Explosive Agents might almost seem a work of supererogation, and I certainly should consider it so—although, possibly, I may have had greater experience than many of those I have the pleasure of addressing this evening in connection with this special subject—if I attempted to discuss it from a purely military point of view. I therefore wish rather to dwell upon such improvements and advancements in the production and application of explosive agents as apply more particularly to industrial operations, that is to say, to operations connected more especially with the mining industry of this and other countries.

In doing this, it will be necessary for me just to touch briefly upon explosive agents with which many of us have long been familiarly acquainted, and more particularly upon the characteristics of gunpowder. Now, gunpowder has enjoyed, as we all know, until the last very few years, quite a monopoly as the explosive agent especially applicable to all industrial operations. One main reason of this is, that it is so old a friend that all who have had to do with mining and similar operations are more or less acquainted with its qualities and properties. Moreover, all who have had to do with explosive agents upon a large scale have more confidence in the comparative safety and permanence of gunpowder than they have in those of any other explosive material which has yet been brought to practical issue. Hence it is that up to the last few years gunpowder has been, practically, the only explosive agent that has been applied on a large scale, not simply to war purposes, but to the various industrial operations in which explosive agents are applicable.

There is, however, another reason why gunpowder presents some special advantages. I allude to the readiness with which the explosive properties of gunpowder may be controlled or modified by simple means; and, in order that I may be able to remind you of these, I must ask you to allow me very briefly to refer to the elementary history of gunpowder: to recall to your minds that

gunpowder is simply a mechanical mixture of a combustible substance and an inflammable substance with an oxidising agent; that these three agents react upon one another; and that the rapidity with which they react depends on the extent of intimacy with which the particles are brought into contact with each other in the mixing or incorporating processes, upon the amount of pressure to which the mixture is subjected, and upon other variable manufacturing processes. Let me remind you that, in the case of gunpowder—the type of a large class of explosive agents with which we are acquainted—we have to deal, in the first instance, with the combustible substance charcoal, in the second place, with the inflammable substance sulphur, and, in the third place, with the substance, neither combustible nor inflammable—in the familiar acceptation of these terms—the substance saltpetre, which possesses the power of burning other substances by virtue of the very large quantity of the oxidising substance, oxygen, which it contains.

In order to illustrate in a simple and familiar way the properties of gunpowder, I mix a particular weight of charcoal with the amount of saltpetre which that charcoal requires for its complete oxidation and conversion into the largest possible quantity of gas which it is capable of yielding. Saltpetre and charcoal will thus furnish us with an explosive mixture—a comparatively feeble explosive mixture, it is true, but still one which would be able to develop a very considerable amount of force. I mix roughly these two ingredients together, and, dividing this mixture very roughly into halves, I spread one half upon this board, and the other half I mix with a particular proportion of sulphur. The latter, by virtue of its inflammability and its great affinity for oxygen, assists in the rapid oxidation of the charcoal by the saltpetre; thus we shall see, by simply burning these two roughly mixed preparations, that the inflammability of the mixture and the rapidity with which it burns are very greatly increased by this addition of sulphur. I need hardly tell you, as regards the quantity of gas evolved from gunpowder, that sulphur contributes nothing; it contributes only to the rapidity and the energy of its action, to the rapidity with which the gunpowder is partially transformed into gaseous matter. I prolong the train formed of these two mixtures by a third powder, which consists of these three ingredients mixed together in the same proportions, but incorporated with very great care—mixed, in fact, as they are, in the actual production of gunpowder. This latter portion will illustrate the great advantage derived from intimacy of mixture in the preparation of explosive agents of this class.

Powder is readily subject to modifications with regard to its explosive character by various means. These may consist, in the first instance, in a variation of the proportions of its ingredients, and still more importantly by varying the intimacy with which the ingredients are mixed, the degree of compression to which the mixture is subject and the size of the particles into which the compressed mass is broken up, and, consequently, the extent of surface exposed to the action of fire. By these several variable conditions we can either intensify or retard the explosive power of gunpowder and of other substances of this description.

I have here samples of gunpowder, all of the same composition; all calculated to furnish the maximum amount of gaseous matter, but simply differing from each other in the size of the particles and in the nature of the surfaces; that is to say, in the extent of glazing and the extent of roundness imparted to them. I will take two or three of these powders in illustration of the extent to which these comparatively simple modifications affect the action of gunpowder. Here is one of the finest grained gunpowders. Here we have the old cannon powder, and here we have the first stride made in the development of the physical characteristics of gunpowder within the last few years. This is the so-called R.L.G. powder, which was prepared especially for use in the first rifled cannon which we introduced into the service. Here is a powder a little larger, which was prepared for the heavier of the first Armstrong guns, and I do not think I can venture, in experimenting, to take a coarser powder. I will, however, take just one piece of what, until we proceeded to the construction of our latest heavy guns, was the largest powder known, namely, pellet or pebble powder. You will observe how very gradually this powder burns as compared with the others, because of the very much larger particle of the individual. Even this powder has been found to be too rapid and violent in its combustion for employment in our own heaviest guns, and we have therefore had to proceed to the employment of powder grains or masses of as large a diameter as $1\frac{1}{2}$ inches with such guns as the 80-ton gun.

I think I have now pointed out sufficiently that powder is susceptible of very considerable modifications in regard to its explosive action; and these modifications have been brought to bear, though somewhat imperfectly, in the application of powder to blasting purposes. Unfortunately, in the case of gunpowder applied to blasting purposes, the tendency has always been to work only in the direction of cheapness. One manufacturer endeavours to cut out another in the production of cheap powder; and this is one reason why gunpowder has, to a very considerable extent, been supplanted

in many of its applications; not because powder might not have been improved to a very considerable extent, but because the powder supplied to the miner has deteriorated in quality in consequence of the tendency to cheapening its production, as the result of competition. Thus, powder produced, not from refined saltpetre, but from the ordinary crude saltpetre, is very susceptible of deterioration by absorption of moisture from the air; and again, powders which are made, not with nitrate of potash, the Indian saltpetre, but with what is called Chili saltpetre, or nitrate of soda, deteriorate very rapidly from the same cause. Powders of these descriptions have been largely manufactured for blasting purposes. Hence it is not surprising that gunpowder has lost some of its reputation, and that the public should eagerly seize upon any more violent explosive agent as offering a prospect of economizing time and labour.

Within the last few years important mechanical improvements have been made in connection with mining operations; and the introduction of boring machines, now so extensively used in connection with the driving of tunnels, has rendered more than ever apparent the importance of introducing improvements in explosive agents—improvements that should enable the explosive agent used to keep pace with the rapidity of operation of the boring machine. Hence boring machines have undoubtedly given a very great stimulus to the employment of explosive agents of a much more violent character than gunpowder.

The oxidizing properties possessed by nitric acid and the nitrates are shared by numerous other bodies known to chemists, among others by a class of compounds of analogous nature to the nitrates, known as the chlorates, in which the large supply of oxygen is held in comparatively very feeble combination by chlorine, as in the nitrates it is held combined by nitrogen. The chlorates are much more readily decomposed, and are, therefore, more powerful oxidizing agents than the nitrates; and hence, when mixed with oxidizable substances, such as carbon and sulphur, they furnish more violently explosive mixtures.

Ever since the chlorate of potash has been produced upon a manufacturing scale, attempts have been made from time to time to utilize its comparatively violent oxidizing power in the production of explosive mixtures more powerful than gunpowder, and applicable to its various uses.

Preparations consisting of chlorate of potash mixed with certain sulphides, with the prussiates of potash, with sugar or starch—these substances being either employed alone or in admixture with sulphur and other substances—have been brought forward at various

times, and under a variety of names, as gunpowder substitutes, the earliest of them being known as German gunpowder, or white gunpowder; but the property which they all possessed of being exploded when submitted to comparatively moderate friction or percussion, was alone sufficient to prevent their being accepted as practically useful explosive agents, even if decided advantages could have been established for them by a proper comparison of their cost and efficiency with those of gunpowder. Ingenious attempts have been made to reduce the dangerous nature of chlorate of potash mixtures, by impregnating or covering them with inert materials designed to serve as protective agents, by absorbing or deadening the violence of blows, friction, or concussion, to which they might be subject; but, while such contrivances were only partially successful in guarding against liability to accident, they so considerably reduced the rapidity and violence of explosion of the materials to which they were applied, as to preclude these from competing successfully with powder from an economical point of view.

A few comparatively safe preparations containing chlorate of potash have, however, been devised, some of which have furnished results in competition with powder, as mining and quarrying agents, so far favourable as to render it probable that they would have met with somewhat extensive application, but for the practical development of another class of explosive agents which have within the last few years become formidable rivals of gunpowder. These chlorate preparations are of several descriptions; one kind consists of mixtures of the salt with organic substances, containing, in addition to carbon, a considerable proportion of hydrogen, such as powdered nut-galls, tannin, and resins. The preparation of powdered nut-galls and chlorate, known as Horsley's powder, which may be considered the type of these mixtures, has been found in practice to possess decided superiority over gunpowder in regard to violence of action, and to be much safer than any chlorate preparation previously used. Another preparation, in which chlorate of potash was applied with comparative safety to blasting and other purposes, was first devised by Messrs. Hochstädter in 1860, and subsequently reproduced, with slight modification, by M. Reichen. Strips of bibulous paper were soaked in a pasty mass, consisting essentially of a mixture of chlorate of potash, saltpetre, charcoal (and small quantities of other readily oxidizable substances), together with a little gum or other binding material dissolved in water. The paper became coated with the explosive mixture, and, at the same time, impregnated with the oxidizing salts, of which it absorbed part of the solution. The strips were rolled up tightly

while wet, and when dry furnished hard and compact cylindrical masses, which were violently explosive when confined, but resisted detonation to a very high degree when submitted to percussion or friction.

Some other comparatively safe applications have been made of chlorate of potash to the preparation of explosive agents for mining purposes, by only partly replacing saltpetre with it in mixtures of similar composition to ordinary gunpowder, or containing sulphides besides free sulphur. A substance called Tutonite, for which special advantages as a blasting agent have recently been claimed, appears to belong to this class of preparations. It possesses the peculiarity of being made up in the form of somewhat hard pellets, or discs, instead of being in the granulated or pulverulent form.

I now pass to a somewhat curious class of explosive agents, in the production of which the primary object aimed at has been safety, both in their manufacture and their use. Here we have such explosive agents as Kellow's blasting powder, another called Pyrolithe, and another termed Purolythe. These substances consist of very crude mixtures of vegetable bodies, in more or less coarse states of division, with saltpetre and with sulphur.

In the production of the first of these the saltpetre was simply poured, in the form of a solution, upon the oxidizable substance, spent tan, which thus was roughly impregnated with the oxidizing agent, and was afterwards peppered with sulphur. Not only, however, has perfect safety been claimed for the manufacture and use of these materials, but in some cases the sanguine inventors have maintained them to be very superior to gunpowder in violence of action. Now, as regards the safety of Kellow's powder, I can certainly bear testimony, for I had some years ago to report upon the possible chances of danger arising to Plymouth and Devonport from a manufactory of this Kellow's mining powder in their vicinity. Not very long after I had inspected the works they were burnt to the ground without an explosion occurring; and the same thing again occurred some time afterwards. As regards the value of such crude preparations when placed in competition with gunpowder, its discussion would be waste of time, and I need hardly say that, although some of them have been brought very prominently before the mining public, they have made little or no way.

Another blasting agent of this class was invented in 1862 by a Belgian officer, Captain Wynants, and consisted of a mixture of charcoal and nitrate of baryta, either alone or with a proportion of saltpetre. The objects aimed at in producing this "poudre

barytique," or "saxifragine," were, in addition to economy, the production of a powder which should act with gradually accumulating force, and which should only be applicable as a blasting powder, so that supplies placed in the hands of miners could not be diverted to other purposes. The first-named object was certainly attained, the baryta-powder being comparatively very slow-burning: and its special characters are such that its application could not but remain limited to ordinary mining and quarrying uses, although its inventor did after a time propose that it should be applied, by admixture with ordinary cannon-powder, to moderate and regulate the pressure exerted by heavy charges in guns of large calibre; a result which has been attained with great success, and in a more philosophical and practically efficient manner, by simple modifications of the physical and mechanical condition of ordinary gunpowder.

It may not be out of place to refer briefly to the fallacious belief, which appears to be frequently entertained by inventors of explosive agents for blasting purposes, namely, that a material which is capable of competing successfully with powder, or of maintaining a superiority over it, in mining operations, must also possess corresponding points of superiority over gunpowder applied to artillery, small arms, and other war purposes. Less smoke, less fouling, and greater penetrative power, are points of superiority often claimed for preparations which, like the mixture of chlorate of potash with nut-galls and similar products, are to some extent successful rivals of gunpowder in its industrial applications, but which cannot be made to combine the comparatively gradual action of powder with the uniformity essential for artillery or small arms. A high explosive power is, furthermore, not the only essential qualification of a powder or other preparation to be employed in shells or in military engineering operations. Freedom from liability to explosion by the violent concussion to which a shell is exposed in the bore of a gun; safety in transport and during manipulations by which the material may be subject to friction or concussion, are among the most indispensable conditions to the application of the explosive agent to service purposes, and are not to be set aside by the impracticable alternative, almost invariably suggested as an important advantage by the proposer of a new explosive mixture, namely, that of keeping the ingredients, which in themselves are harmless, separate until just before the material is required for use, thereby postponing any risk of accident, but accumulating it within a period when it can least readily be guarded against, and resorting to wasteful expenditure of sources of force, in the shape of crude mixtures, as a means of partially

counteracting those very properties which render the material specially valuable when applied to its legitimate uses.

Before passing to the more important of the new explosive agents which I wish to discuss, I must briefly refer to one other class of explosive mixtures, of which either saltpetre or chlorate of potash is an essential ingredient, because, though their application to blasting purposes has only been attempted to a limited extent, they have lately attracted some attention, as being agents of considerable power.

Among the numerous products obtained by the action of nitric acid upon materials of organic (animal or vegetable) origin, one of the earliest discovered, possessing explosive properties, is the product known as picric acid, or carbazotic acid, which is furnished in that way by indigo and various other organic substances. Though discovered in 1788, it was only prepared in small quantities until within the last twenty years, but it is now readily manufactured from the coal-tar product known as carbolic acid, and has recently become an important article of commerce as a cheap and brilliant yellow dye. Its salts are all more or less explosive, the picrate of potash, one of those most easily prepared, being especially so. This, when mixed with saltpetre or chlorate of potash, particularly with the latter, furnishes products which, in violence of action, more nearly resemble gun-cotton and nitro-glycerine preparations than does any other readily-procurable explosive agent. Both mixtures are susceptible of detonation by friction, and especially that containing chlorate of potash, which is, indeed, inapplicable to practical purposes on account of its dangerous nature. M. Designolle devoted considerable attention, a few years ago, to the production of safer mixtures of picrate of potash for artillery and small arms, and for blasting purposes; one of these, consisting of picrate of potash, saltpetre, chlorate of potash, and charcoal, was experimented with at Le Bouchet on a considerable scale about four years ago with some favourable results; but the experiments were abandoned in consequence of a disastrous explosion which occurred at a factory in Paris where considerable quantities of picrate of potash were stored.

Some years ago it became very important to us to have a more powerful agent than gunpowder for employment in shells, such as the Palliser shells, in which there is a very small space; and my attention being directed to the subject, I experimented with picrates, and produced a very safe explosive agent by incorporating saltpetre with picrate of ammonia. This substance, to which I gave the name of "Picric Powder," may be manufactured and used as safely as ordinary gunpowder. It is dearer, but very considerably more

powerful, and may be produced readily upon a large scale, the only drawback being that the workman or the artilleryman, in his manipulation of it, has to swallow a certain amount of dust of a very disagreeably bitter taste. This picric powder has been experimented upon on a considerable scale. Its explosive power depends to a large extent upon the rapid development of aqueous vapour; in fact, it is a steam generator. The very manner in which it burns gives you an idea of this characteristic, for as it burns there is a peculiar hissing noise, and a large cloud of vapour is given off, consisting mainly of steam. This powder was fired, with battering charges, in shells of the largest calibre which we had till within a comparatively brief period, and was used with safety, and it appears likely still to prove of importance for war purposes. How far it may be applied to industrial purposes with advantage remains still to be seen.

All these different explosive agents which have been touched upon, though they may, here and there, possess certain valuable properties, will not bear comparison in importance with those which have received extensive application within the last ten years, namely, gun-cotton, and nitro-glycerine. I need hardly tell you that both these substances have been known to chemists now for a considerable number of years.

In 1833 the first preparations analogous to gun-cotton were produced by Frenchmen, by acting upon paper and linen or cotton fabrics, and upon starch, with nitric acid, but no practical application of these substances was attempted, and it was not till Schönbein, in 1845, found that cotton wool could be readily converted into a violent explosive agent by being soaked in a mixture of nitric and sulphuric acids that any attempt was made practically to apply this class of explosive agents. Here is a specimen of gun-cotton which, within a year of its discovery by Schönbein, I, as a young chemical student, prepared, in 1846; and I refer to it as a proof of the permanence of that material. That specimen of gun-cotton was lying in a box for a number of years, and I used to amuse myself by puffing off pieces for the benefit of my friends; but when it became a specimen of historic interest I had it bottled and exposed to light, and there is the sample that was produced in 1846. Here is another specimen which was produced by a well-known chemist, Jacob Bell, in 1850—the one just thirty years old, and the other not much younger. In the first instance, when Schönbein produced this explosive cotton or gun-cotton, he came to England, of course, anticipating that Englishmen, with their well-known tendency to apply scientific discoveries to practical purposes, would at once work out the discovery without

much difficulty, and, indeed, the Messrs. Hall, the well-known powder makers, soon entered zealously into the matter, and proceeded to manufacture gun-cotton upon a considerable scale at the beginning of 1847. They produced mining cartridges, of which this is an interesting specimen, which I was enabled to obtain in the North not very long ago. The gun-cotton wool is, as you see, tightly compressed into a case, so tightly compressed that it burns very slowly and regularly. It has preserved itself thoroughly. In this form gun-cotton was first of all presented to the miner; it was at once found to be a most marvellous explosive agent, and it was applied with very considerable success within a few months of its discovery. Unfortunately Messrs. Hall, not well understanding the manufacture, or thoroughly acquainted with the nature of the material, had a most disastrous explosion, and immediately put a stop to the manufacture, and buried a considerable quantity of the gun-cotton, a portion of which I induced them to unearth not many years ago, when it was found in its original good condition.

Gun-cotton possesses some properties which at once attract the attention of the scientific, as well as of the practical man; for instance, the fact that it burns without leaving any residue or producing any smoke, whereas in the case of gunpowder we have always a large quantity of smoke. Then, again, the rapidity of its explosion is another property which at once strikes one who is acquainted with the various explosive agents, as a matter of considerable importance; the rapidity being so great that there is, for example, no difficulty in igniting gun-cotton which is in contact with gunpowder, without any fear of igniting the powder itself. In fact, we may even envelop the grains of gunpowder in gun-cotton and ignite the gun-cotton without thereby inflaming the powder. But these properties appeared to be accompanied by certain defects; one of these, for example, was the development of acid matter when gun-cotton was exploded. This can be readily demonstrated, as also the fact that in the case of the ignition of gun-cotton we have a large amount of inflammable gases given off. In the experiment I now proceed to give you, in which I ignite a tuft of gun-cotton in a partially confined space, there will be observed, after the first flash, a pale lambent flame, which will flicker in the vessel for a long time, and which flame is due to the development of carbonic oxide gas by the ignition of the substance. In gun-cotton there is not a sufficient amount of oxygen to convert the whole of the carbon into carbonic acid, and therefore we really only utilize thoroughly a part of the carbon which the gun-cotton contains. After a time we see that there is produced by the ignition of the gun-cotton in this experiment a quantity of nitric oxide,

which becomes nitrous acid by mixture with air, and is rendered visible by the brownish colour it produces. This development of acid appeared a most important objection, and an objection it certainly would be if this occurred in practical use; but when gun-cotton is confined its products of explosion are very different from those produced when it is ignited in the open air. The pressure developed by the first ignition of gun-cotton in a confined space brings about a more complete action of the constituents upon each other, and we have consequently no trace of acid or nitric oxide developed by the burning of gun-cotton in a confined space. The whole of the oxygen is utilized in the oxidation of the carbon and hydrogen, and still more might be used if we could introduce it into the composition of the material, which can, however, only be done by the addition of some oxidizing agent in the form of a mechanical mixture.

The explosion which occurred at Hall's factory was very speedily followed by explosions in France, in which country they were also attempting to apply gun-cotton largely to mining operations, and this led to the entire suspension of the application of gun-cotton in both these countries; but the Austrians continued to persevere, and an Austrian officer named Von Lenck devoted himself to elaborating a means of controlling its explosive character, with a view of rendering it more readily applicable to war and to industrial purposes. He proceeded about this in a very ingenious manner. He converted gun-cotton into threads of different degrees of fineness, and wound or plaited these to different degrees of compactness or density, and by these simple means obtained, when experimenting in the open air, what appeared to be most marvellous modifications of the burning of gun-cotton. I will just take two or three of these specimens of gun-cotton prepared by Von Lenck, and show you how, by the simple means which he employed, it appeared at first sight that almost everything had been obtained that could be desired in the modification of the explosive character of the material. There is a piece of plait, here is a coarse thread of gun-cotton, and here I have a finer thread. I lay these together end to end, and proceed to light these three by means of a spark. We first notice a combustion, which can hardly be called burning at all—the flame is creeping along under great difficulties. Presently, when that little flame reaches the coarser gun-cotton, it bursts into a large flame, and we have a much stronger burning, and finally an explosion when it reaches the piece of plaited gun-cotton.

Although I may be tempted to dwell somewhat too much in detail upon the different effects produced in this simple experiment, I cannot resist doing so, because the phenomena it

exhibits really lie at the root of the question as to the manner in which the modification of these explosives affects, in so important a way, their application to the different operations required. You noticed just now that little tongue of flame which was produced by lighting, by means of a spark, a comparatively fine description of gun-cotton. I will repeat that experiment, and show you that that little tongue is produced simply because we are, in that particular case, not burning the whole of the gun-cotton. If I apply a body heated to whiteness, I not only ignite the gun-cotton, but also those inflammable gases developed by its burning, to which I just now called your attention. The gun-cotton includes a large quantity of carbonic oxide, and if I ignite it simply by a spark, the gun-cotton burns; but that inflammable gas is not raised to a temperature sufficient for its ignition; and, in fact, if that gun-cotton were still more closely twisted, those gases, as they are evolved, would carry away so much of the heat developed that the piece of gun-cotton would extinguish itself. Here we have the gases evolved when the gun-cotton is ignited with a red hot instead of a white hot body. I now allow a strand of gun-cotton to burn in this slow manner inside a glass test-tube, and you see I can inflame the gases evolved by applying a flame to the mouth of the tube. It is remarkable how readily this particular form of burning gun-cotton may be brought about. If we can cause these gases to pass away sufficiently quickly, or if we can for a moment prevent them from surrounding the burning gun-cotton, thus preventing the flame from enveloping the gun-cotton, we can cause the phenomenon of combustion to pass readily from one form to another. Thus, I take a card, simply perforate it, and pass a strand of gun-cotton through the perforation. Now I light it in the ordinary manner by means of a flame. When the gun-cotton flame reaches the perforation, having to pass through that narrow orifice, the gases are for a moment prevented from surrounding the burning portion of the gun-cotton, and cease to burn in consequence, and the combustion of the gun-cotton passes from the quick to the slow form. One is able to actually brush out the quick flame of gun-cotton and make it pass over into the slow flame simply by the operation of the hand. If I afterwards hold the gun-cotton up in the air, with the end downwards which is burning slowly (the air in this room happens to be moderately still), the heated gases will ascend and surround the small point of flame, and become raised to a temperature sufficient for ignition. (Experiment showing this result.) These are illustrations of the comparatively ready manner in which the explosive nature of gun-cotton can be modified in open air. But it soon became apparent,

in attempts to control the explosion of gun-cotton in this direction, that although it could be moderated in its action when burnt in air, when in a confined space, this no longer occurred; because, even when the gun-cotton threads were very tightly wound or plaited, it was found, that under the pressure produced by the development of the first portions of heated gases, these gases penetrated into the mass, and conveyed the necessary heat for explosion with very great rapidity throughout the charge.

In 1863 a violent explosion occurred in Austria, in a gun-cotton magazine, and as the result of this, the Austrian Government determined to abandon their experiments with gun-cotton; they then generously offered the English Government the secret of Baron von Lenck's plan of making and applying gun-cotton, and the result was, we instituted systematic investigations with gun-cotton, and eventually arrived at the results with which you are acquainted, and which have led to the material becoming really valuable for warlike and industrial purposes. By simply reducing gun-cotton to a fine state of division, the system, which is applied in the manufacture of gunpowder to the production of masses of different sizes and of different densities, can be successfully applied to gun-cotton, and a material obtained, the explosive force of which has been found comparatively very controllable, and which, by the subsequent application of detonation to gun-cotton, became at once susceptible of very ready employment as a most violent explosive agent; hence it is that gun-cotton, which for a time appeared to have altogether vanished as a useful explosive agent, became developed into the valuable material with which we are now so familiar.

Now, side by side with that of gun-cotton, the application of nitro-glycerine has been developed, and that mainly through the energy of a Swedish engineer named Nobel; and this was done by a series of investigations, embracing failures and partial successes, which it would take me much too long to attempt to follow; so I will endeavour very briefly to point out how Mr. Nobel eventually succeeded in applying nitro-glycerine as a useful explosive material. He first of all attempted to use this explosive agent in its liquid form. This material, which was discovered about the same time as gun-cotton (in 1847), by an Italian chemist (Sobrero), was for a long time simply regarded as a chemical curiosity, on account of its apparently very unstable character, and its violent and uncontrollably explosive nature. But Mr. Nobel continued to labour steadfastly in the endeavour to bring it to a practical issue. He first applied nitro-glycerine in conjunction with gunpowder by impregnating the grains with nitro-glycerine, and thus produced a very violent explosive agent, but one very uncertain in its action.

In applying the substance in its liquid form, Nobel found it impossible to insure the explosion of the substance simply by the application of an ordinary fuze, even when it was strongly confined. He then had recourse to one or two ingenious expedients, with a view to obtain its explosion with certainty. Thus, he used what he called heaters—gunpowder cartridges, or large pieces of wire heated by electric agency—by means of which the explosion was brought about. But not until he had hit upon the expedient of exploding it by detonation, that is, exploding in contact with it a small quantity of a violent detonating material, did he obtain anything like certainty of action. By exposing nitro-glycerine to the detonation of a small charge of fulminate of mercury, Nobel succeeded in effecting the explosion of the material with a fair degree of certainty. A smart blow, very much like that of a hammer, is thus applied to a small portion of the material, which being confined is powerless to yield mechanically to the blow, and the result is that great heat is suddenly developed in those portions, and chemical disintegration or sudden decomposition ensues; and this is the action which takes place when compressed gun-cotton or nitro-glycerine (for gun-cotton in the compressed condition is susceptible of the same kind of action) is subjected to the influence of a detonation. Mr. Nobel first of all applied this detonation with great success, though not with certainty, to liquid nitro-glycerine. Sometimes, however, the nitro-glycerine failed altogether; that is, sometimes it would yield to the blow, and not even be inflamed. But there were other important objections to the use of nitro-glycerine in the liquid state. If poured into a blast-hole, for example—and it very seldom happens that a blast-hole is perfectly sound—a portion of the material, being liquid, might find its way into fissures and cracks, reaching, it may be, to some distance; and this hole having, perhaps, failed to explode in consequence of the escape of the nitro-glycerine, the miner, in boring into the rock in the neighbourhood with his iron tool, might one day come upon some portion of the nitro-glycerine which had thus escaped, and by subjecting it accidentally to violent friction, bring about a disastrous explosion.

Again, a number of disastrous accidents occurred in transporting the liquid material, from leakage and other causes. After a time Mr. Nobel conceived the idea of mixing the nitro-glycerine with porous solid substances, and thus of producing plastic preparations in which the nitro-glycerine was presented to the miner almost in the nature of a solid, but a solid of a very convenient form. Here is one of these preparations, the so-called No. 1 dynamite, which consists simply of nitro-glycerine, mixed with about one-fourth its weight of a very porous material—of a material, indeed, which

acts simply like a sponge—the substance known as kiesel-guhr, which is a siliceous earth found in Germany. By saturating this with the nitro-glycerine we obtain a material very similar in its character to putty, from which the nitro-glycerine may be very readily separated by means of water: on stirring it up with water the nitro-glycerine falls to the bottom, and the kiesel-guhr is suspended in the water. This material, so long as comparatively small quantities are operated upon, may be ignited without any fear of an explosion resulting. Here is a small quantity of the dynamite, which burns fiercely, but still moderately. This bulky substance, which is left after the combustion, weighs hardly one-fourth of the original material. In this form nitro-glycerine is very readily applied, and in some respects possesses advantages over the comparatively rigid substance, compressed gun-cotton; thus, being plastic, it can be rammed into holes of irregular form, and the cartridge may be made to occupy a comparatively small space; and this undoubtedly is an advantage, but an advantage which has been recently counterbalanced by the application of gun-cotton in a granulated condition. In that form it is also readily susceptible of being rammed into irregular holes. One disadvantage of dynamite is its liability to freeze; and this is a disadvantage, not because it then becomes specially dangerous, but because it thus becomes, comparatively speaking, inert, and either requires special arrangements to effect its detonation, or must be thawed before it is used. It is this necessity for thawing which has led to the frightful accidents of which we are frequently hearing in connection with the application of dynamite in blasting operations. The miner is by nature a reckless man. Probably this recklessness is to a large extent the result of ignorance; but it also arises in part from his living constantly among dangers and becoming callous to them, and, at last, comparatively indifferent to personal safety. That occurs also in the case of the man who supplies the miner with his explosive materials. The accidents due to frightful recklessness are so remarkable, and some of them so curious, that I should like, if I had time, to give you something like a catalogue of those recorded. Without doing this, however, I will just refer to one or two, in illustration of how such a substance, for instance, as gunpowder is dealt with. A miner will, as a matter of habit, make up his mining-straw (that is, a species of match consisting of damp gunpowder rolled up in paper or rammed into a straw) in his dwelling-room, while eating his dinner, or directly after his dinner, and with a quarter-barrel of gunpowder by his side, possibly his pipe in his mouth and his child playing at his feet. Instances are recorded of lucifer matches having been given to the children to play with in

rooms where these operations are conducted. Then, again, the men who sell or serve out powder are often known to treat it in the most extraordinarily reckless way. As an instance, the case is officially quoted of one man resorting to the practice of boring holes into a barrel with a red-hot poker, instead of using an auger. In one instance the head of the barrel happened to be rather thinner than those which had been operated on before in this very original manner, and the man fell a victim to his temerity. These are only one or two illustrations of the apparent utter want of thought in connection with the application of gunpowder. In many instances the powder is served out from small magazines open to the road; and in one such instance some children were observed to be playing with something on the ground, which proved to be powder-grains which had been spilled from the packages when carried out of the magazine. Eventually these grains were formed into a train leading to the door of the magazine, which was fired by their ignition. Instances of carelessness of this kind have been of constant occurrence. Then the carrying about of powder in public conveyances has been regarded quite as a matter of course. At Wigan, not long ago, a man who got on the top of an omnibus was requested to extinguish his lighted pipe, as the man sitting next to him had a keg of gunpowder between his legs. Examples of recklessness fully as great as these have frequently occurred with such explosive agents as dynamite and gun-cotton; and the miner has been taught to believe that they are only explosive when applied in conjunction with a detonating cap. He habitually keeps his dynamite in his pocket, to be ready for use; in fact, one of the original instructions to the miner was that he must carry it about his person to keep it from freezing. He even takes his cartridges to bed with him, in order to keep them warm and ready for use in the morning. It is in consequence of such modes of dealing with this material that the various frightful accidents of which we read occur; and it must be said that the vendors, and also many of the manufacturers, are very largely to blame for the utter disregard of precautions which occur among the miners. Thus, such substances as the so-called cotton-powder, which is now produced at Faversham, are supplied to the miners (under the new designation of *tonite*) with labels to the effect that the substance is absolutely safe, and will not explode under any circumstances until the detonator is applied. The result has been the death of three or four men, and has very nearly led to the bringing in of a verdict of manslaughter against the manufacturers of the material.

So long as those interested in the sale of explosive agents culpably mislead the ignorant, and so long as mine and quarry

owners are not careful to inform themselves and their men of the properties of the destructive agents with which they deal, so long must we expect continually to hear of lamentable accidents for which the operatives themselves are not to blame, in addition to those which arise from pure recklessness.

There are many other explosive agents besides dynamite and compressed gun-cotton which I might, if time allowed, call your attention to; but they possess at present no great practical importance; in fact, I may say that they are all mere imitations of these two materials. Naturally enough many desire to benefit by the application of these important agents, but in the case of most of the attempts hitherto made to produce so-called improved preparations, there is simply the semblance of originality. Thus, we have a substance called patent gunpowder, which is simply a very imperfect gun-cotton made from wood fibre. Then we have here the so-called cotton-powder, or tonite, a mixture of gun-cotton with nitrate of baryta, with or without the addition of carbon. Then we have a variety of dynamites, and we also have a substance which has become somewhat well known under the name of lithofracteur, and which consists of a mixture of kiesel-guhr, nitrates, and carbon, with a smaller proportion of nitro-glycerine than in ordinary dynamite. It is a black plastic preparation, which is similar in character and explosive power to some kinds of dynamite prepared by Nobel. One great defect of preparations of this class, and one that is a source of very great danger, consists in the liability to the exudation of nitro-glycerine from the material. When this kind of dynamite is first prepared, it does not even soil paper in which it may be wrapped, but the nitro-glycerine it contains has a tendency to freeze at a high temperature, namely, at about 45° Fahrenheit, and the repeated freezing and thawing developes a tendency to exudation, which sometimes causes considerable quantities of nitro-glycerine to separate and become a source of very great danger. With the preparations made in imitation of dynamite this exudation occurs more considerably than with the preparation which consists only of kiesel-guhr and nitro-glycerine, and constitutes one of the great drawbacks to their application. Undoubtedly the kiesel-guhr preparation is the one which presents the nitro-glycerine in the safest form; it is the most powerful of all nitro-glycerine preparations, and is the one which, therefore, is used much the most extensively.

It may be expected that some definite statement should be given of the comparative effects, as mining and blasting agents, of gunpowder and of the violent explosive materials which have been more especially referred to. Excluding nitro-glycerine in its pure

or liquid form as pre-eminently dangerous, and therefore only likely to receive exceptional application, and taking dynamite and compressed gun-cotton as fairly representing the really useful explosive agents of the violent class, it may be stated, generally, that in all operations where rapid destruction is to be accomplished, as in the instances just referred to, gunpowder is incontestably inferior to those explosive agents. Not only would a much larger quantity of powder be required to produce similar results, but, in some instances, it would be impossible to perform the same operations even with exorbitantly large charges of powder. This is especially the case in the breaking up of masses of hard rock or metal by the superposition, or simple insertion into cavities, of the explosive agent. Again, in tunnelling and blasting in hard rock, the new explosive agents represented by dynamite and gun-cotton possess undoubted advantages. Important economy is effected by their use, not simply in regard to cost of material to produce equal effects, but in regard to saving of labour, of tools, and of time. Short charges and long tamping (which need not be hard tamping) insure the breaking up of the hole to the bottom, and generally tend to break up the rock beyond the bottom of the hole. The holes may be of smaller diameter, and are more rapidly loaded; the latter being especially the case with holes which are horizontal or driven at an upward angle.

Practical experience with compressed gun-cotton in North Wales, which no doubt also bears upon the employment of dynamite, has shown that in tunnelling in the slate quarries, where sixty shillings per yard has to be paid when gunpowder is used, the same quantity of work can be done, and in less time, for forty-five shillings per yard.

The shattering and splitting effect of dynamite and gun-cotton in hard rock is much greater than with powder, but, in quarrying, the rock is generally not thrown off by them to the same extent. It is frequently found advantageous, in rapid working, to drive large and deep holes far back from the face, and charge these with the violent explosive, by which the rock is extensively fissured; large quantities of powder are then poured into the fissures, and by its explosion enormous quantities of rock are removed. In submarine blasting, a similar mode of combining the shattering and displacing effects of the violent and gradual explosive agents have been found very advantageous. In submarine demolitions, as in the destruction of wrecks, the violent explosives generally have a decided advantage; but in some operations upon iron ships it has been found that the lifting effect of large charges

of powder is advantageous in clearing away framework and other parts which have been shattered, but not actually removed, by the more violent explosive agents.

When a moderate cleaving and separating effect is required, accompanied by as little local action as possible, gunpowder cannot at present be advantageously replaced; as, for example, in the raising of large blocks of the finest slate. In other instances, of less frequent occurrence in industrial works, but which may be of some importance in military operations where great displacing action is required, gunpowder has the undoubted advantage. In the submarine blasting of very soft rock, such as soft limestone or chalk rock, the comparatively instantaneous action of the violent explosives operates disadvantageously in regard to their displacing power. As an illustration of this, some experiments made under Sir J. Hawkshaw's direction in June, 1870, upon the foreshore near the Shakespeare tunnel, at Dover, may be referred to. The object was to ascertain whether the detonation of gun-cotton charges, placed upon the surfaces of submerged soft chalk rock, would break up the latter to such an extent as to facilitate its rapid removal by dredging. The results showed that the rock was completely disintegrated, or pounded into a plastic mass like clay, within a comparatively limited area; but that the shattering or rending of the rock did not extend to any considerable distance, as it would have done in the case of hard rock, of which the portions contiguous to the charge would have presented greater resistance to the blow exerted by the extremely rapid explosion. Numerous experiments made in this and other countries with gun-cotton and dynamite have shown that the violence of the concussion due to the suddenness of the explosion gives materials of this class important advantages over gunpowder for use in submarine mines.

Though it may be comparatively easy to point out, generally, the peculiar practical advantages which these violent explosive agents possess over gunpowder, it is exceedingly difficult, indeed impossible, in the existing state of knowledge, to give any precise information as to the equivalents of such materials as dynamite, gunpowder, gun-cotton, &c., or to state, even in regard to special applications, how much of the stronger explosive is really equivalent to a given weight of gunpowder or of some other material. Such statements are, however, constantly made, and with great confidence; thus I even heard a particular nitro-glycerine preparation spoken of as having, in some rough experiments, produced a result ten per cent. better than that of another similar preparation.

Very serious difficulties attend any attempts to institute a strict comparison between the destructive effects of different explosive agents, and there can be no doubt that, at any rate at present, long-continued use of two materials in the same class of work can alone determine their relative merits by the average results furnished. With regard to dynamite (which it is presumed may be considered certainly not inferior to lithofracteur) and compressed gun-cotton, it may be stated generally, but with reserve, that in ordinary blasting operations, the results furnished by them, weight for weight, are accepted as being about six times those produced by gunpowder. In comparing the effects of dynamite containing 75 per cent. of nitro-glycerine with those of gun-cotton, the two materials appear to be practically on an equality as regards power, weight for weight; but dynamite has this advantage, which is shared by similar preparations, that in rugged and uneven holes, a somewhat larger charge can be introduced into a given length of hole, because its plasticity permits of its being made by gentle pressure to completely fill the space allotted to the charge, while the rigid gun-cotton will not accommodate itself to irregularities in the shape of the hole. With regard to other special advantages of either of the explosives named, the most prominent one of dynamite is, that it may be used in a damp hole without fear of its missing fire, while, on the other hand, compressed gun-cotton possesses the advantages that it is not in any way injurious to handle, is not at all affected, in its ready explosiveness, by cold, and may, if necessary, be preserved, and even used in blasting operations in the damp, perfectly uninflammable state, through the agency of a small primer of dry gun-cotton.

In concluding this very imperfect outline of the history of those modern explosive agents which have attained importance in connection with industrial operations, permit me to express the gratification which it has afforded me, after an interval of many years, to lecture once more to an audience at the Royal Engineer Establishment, with which I have had the pleasure of being so long intimately associated.

Colonel Stokes proposed a vote of thanks for the valuable and interesting lecture which Professor Abel had given them, and for the trouble he had taken to come so far to deliver it; and expressed the hope that it was not the last time they should hear him. He was sure that it must have occurred to most of them to observe the extreme modesty with which Professor Abel had touched upon the subject of the perfecting of gun-cotton in this

country, when it came here as an explosive agent which other nations had failed to render available; for he believed he was correct in saying, Professor Abel had at that juncture most effectually helped on the discovery of the mode in which gun-cotton might be practically and safely used.

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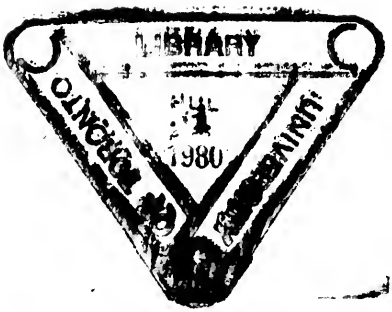
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